ISSN 0377-9335

entomon

A Quarterly Journal of Entomological Research

Vol. 6 SEPTEMBER 1981 No. 3

PUBLISHED BY
THE ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY
DEPARTMENT OF ZOOLOGY, UNIVERSITY OF KERALA, KARIAVATTOM
TRIVANDRUM, INDIA 695 581

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Books: NAYAR, K. K (19 3) *Elements in Insect Endocrinology*, Prentice Hall, India, 26pp. *Chapter in a book compiled and edited*: GILBERT, L. I. & D. S. KING (1973) Physiology of growth and development: Endocrine aspects, 149—370, *in: The Physiology of Insecta*, Vol. **1,** 2nd ed. (ed. ROCKSTEIN, M), Academic Press, New York & London.

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entomon

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THE ANATOMY AND HISTOPHYSIOLOGY OF THE ECDYSIAL GLANDS OF *ACHOEA JANATA* LINN. (LEPIDOPTERA:NOCTUIDAE) DURING POST-EMBRYONIC DEVELOPMENT

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(*Received 14 March 1981*)

The ecdysial glands (EGs) of *A. janata* Linn. have been studied during the post-embryonic development using Halmi's mixture and eosin-haematoxylin staining techniques respectively.

The EGs of *Achoea* are "compact cum diffused" type which lie on either side of the prothorax, dorsal to the 1st spiracle. The gland cells are triangular or rectangular in form and are of compact nature during the early developmental stages (1st to 3rd instar larva) but later, become oval or spherical in shape. The glands are innervated by 4 pairs of nerves viz., suboesophageal transverse, prothoracic transverse, mesothoracic transverse and medial-1. In each gland, 18 cells in 2nd instar, and 73 cells in the 5th instar larvae have been recorded, which is the average number of cells in a gland. In pupae each gland is composed of about 64 cells. Number of cells increases at each larval instar. At the mid of each instar, the size of the gland cells increases showing enhanced activity. The most active cells are characterised by having a large volume of cytoplasm with vacuoles and highly branched nucleus. The maximum activity in EGs was observed on the 4th day of the last larval instar. The histological changes at larval-pupal and pupal-adult moulting were also studied and described in detail.

(Key words: corpora allata, corpora cardiaca, neurohaemal organ, neurosecretory material, histophysiology, ecdysial glands, *Achoea janata*, post-embryonic development)

INTRODUCTION

HERMAN & GILBERT (1966) and HERMAN (1967), have studied the ecdysial glands of *Hyalophora cecropia* in considerable detail. They have classified the EG into "diffused" and "compact" types. In the former type the cells are haphazardly distributed in the thorax and connected to each other by filamentous structures whereas in the latter type i.e. "compact", the glands are typically more or less compact organs and located in the head region. The EG of *Achoea* differs considerably in the arrangement of cells and innervation. HERMAN & GILBERT (1966) is of the opinion that each of the moulting i. e. larval-larval, larval-pupal and pupal-adult of the developmental stages reveal some minor but characteristic changes in the internal structure of the glands. A similar view, in the last two moulting cycles (larval-pupal and pupal-adult) have been expressed by SRIVASTAVA (1960). In the present work a detailed account of the anatomy and histophysiology of EG of *A. janata* during the post-embryonic development has been given.

MATERIALS AND METHODS

The newly emerged 1st instar larvae were collected from the castor plants (*Ricinus communis*) in the month of July, which were reared and maintained in the laboratory on the fresh and

healthy leaves of castor plants (*Ricinus communis*). For securing animals of proper age, the larvae were isolated from the gross culture at the time of moulting and were kept in separate cages. Dissections were performed in saline as described earlier (SINGH & AWASTHI, 1980). Counting of the gland cells as well as their innervation was studied *in situ* by injecting 1% methylene blue solution, 15 minutes before the dissections. Whole mounts of ecdysial gland (EG) were prepared using borax carmine. The glands were fixed in Bouins fluid and stained with HALMI'S (1952) mixture and routine eosin-haematoxylin techniques in the sections cut at 8-10 μm thick, for investigating the cyclic activity of the gland cells.

OBSERVATIONS

The results described in the present work are based on gross dissections and histological observations made on all the developmental stages (i. e., from 2nd instar to 5th instar larvae, pupae and adults).

Location of the glands

The EGs *Achoea janata* lie mainly on either side in the prothorax and are ventrolateral in position. In larvae, the main cluster consists of compact gland cells, situated dorsolateral to the 1st spiracle towards the innerside. Normally, 1 to 3 cells thick cord arises from the anterior part of the main cluster of the EG which runs upto the head capsule where it bifurcates into two branches. Other branches, that radiate from the main cluster are found associated with the tracheal branches. Posterior to the 1st spiracle, the gland cells are totally absent. In pupae, the gland cells hold almost the same position as found in the larvae. However, they come closer to the brain, due to the retraction of the thoracic segments. In late pupae, the gland cells are loosely arranged and are found scattered in the thoracic region. The cords at this stage gives a beaded appearance.

Innervation of the glands

The EGs of *Achoea janata* are innervated by at least 4 pairs of main nerves which arise from the thoracic ganglia. One pair of nerves arise from each suboesophageal, prothoracic and mesothoracic ganglia, and accordingly they are labelled as suboesophageal, prothoracic and mesothoracic transverse nerves respectively which innervate the various parts of the gland (Fig. 1). In addition to aforesaid nerves, one more nerve i. e., medial-1 arises from the posterior part of the prothoracic ganglion and innervates the main cluster of the gland. Furthermore, two lateral nerves viz. lateral-1 (L-1) and lateral-2 (L-2) arise from the mesothoracic transverse nerve (MTN) also innervate the gland. The L-1 nerve joins the transverse nerves of the M-1 and the L-2 nerve innervates directly the gland cells. Although metathoracic transverse and medial-2 nerves are present they do not innervate the glands since the latter are absent in the mesothoracic and metathoracic segments (Fig. 1).

Number of the gland cells

The gland cells were counted from 2nd to the last instar larvae (i.e., 5th instar), prepupa, mid pupae and average number of cells was recorded (Table 1). About 18 cells were found in each gland of the early 2nd instar and 73 cells (in each gland) in the late 5th instar larvae. The average number of cells in each gland is given in the Table 1. Although it is a bit difficult to count the exact number of the cells in the pupae due to the presence of a large amount of fat bodies but approximately 64 cells were found in each gland in the pupal stages. The EG are absent in the adult moths since they degenerate before imaginal ecdysis.

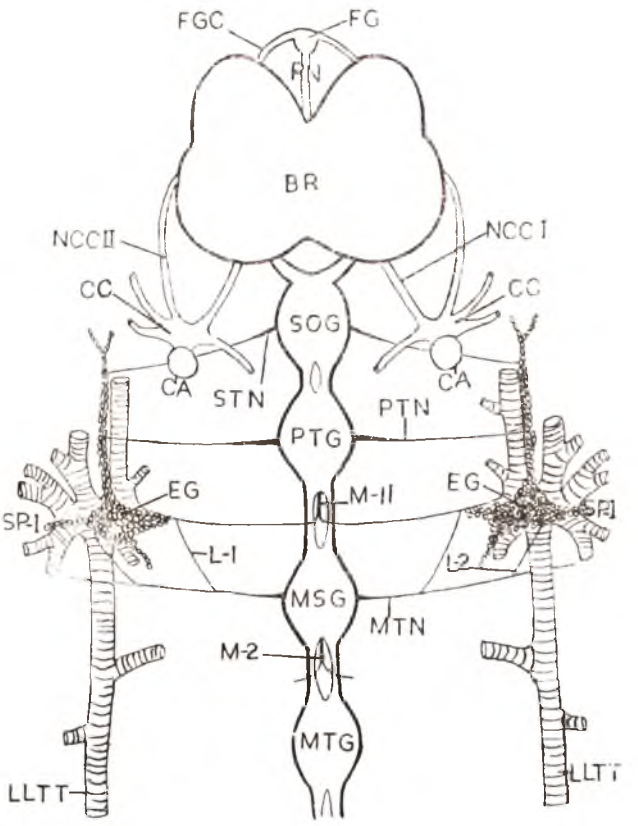


Fig. 1. Diagrammatic representation (not drawn to scale) of the anatomical interrelationships of the various components of the neuroendocrine organs of a mature larva of *Achoea janata*. Br, brain; CA, corpora allata; CC, corpora cardiaca; EG, ecdysial gland; FG, frontal ganglion; FGC, frontal ganglion connective; LN-I, lateral nerve-I, LN-II, lateral nerve-II; LLTT, lateral longitudinal tracheal trunk; M-I, medial-I, M-II, medial-II; MSG, mesothoracic ganglion; MTN, mesothoracic transverse nerve; NCC-I, Nervi corporis cardiaci-I; NCC-II, nervi corporis cardiaci-II; PTG, prothoracic ganglion; PTN, prothoracic transverse nerve; RN, recurrent nerve; SOG, suboesophageal ganglion, SP-1 spiracle-1; STN, suboesophageal transverse nerve.

Gland cells

In the freshly dissected individuals, the glands are not clearly discernible due to their dull-white colour but they can be easily seen after fixing briefly in Bouin's fluid.

As already stated, the glands are mainly restricted to the prothorax close to the 1st spiracle. The gland cells are very compact from 2nd to 3rd instar larva. The closely packed cells are either rectangular or triangular in outline (Figs. 21, 24). Occasionally, they appear polygonal in shape. The cells become oval (Fig. 3) or elongate or rectangular in shape from 3rd instar onwards (Figs. 2, 5). But it is interesting to note that the cells of the main cluster (in larval instars) remain almost rectangular in form (Fig. 2). The cells are attached to each other as well as to the neighbouring tissues by means of thin,

TABLE 1. Mean number of cells of *A. janata* in each EG during the post embryonic development

Stages	Larval instar II	III	IV	V	Pupa	Adult
Early	18	27	48	65	71*	—
Middle	21	37	50	70	64	—
Late	24	43	53	73	?	—

* Prepupa

acellular filaments that maintain the proper position of the gland in the body. The EG cells of the early pupal stage are loosely attached to each other but are found scattered haphazardly in the prothorax in the late pupa. Most of the cells are spherical in shape in the late pupal stages.

The gland cells are richly innervated as well as profusely tracheated by the fine tracheal branches (Figs. 7, 13). It was also observed that the fine tracheal branches penetrate the glands and almost each cell receives a tracheal branch.

Size of the gland cells

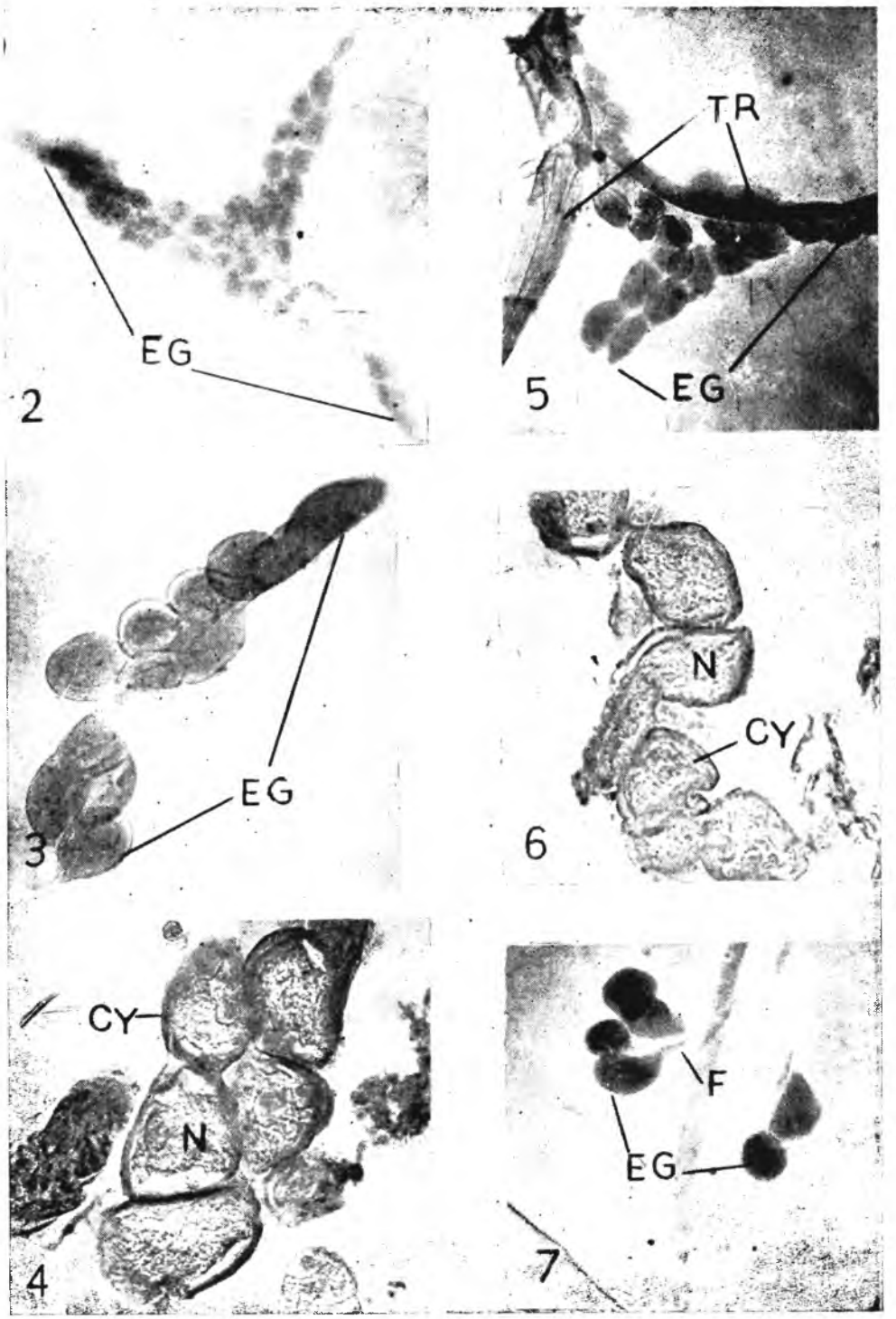
The size of the EG cells from 2nd to 5th instar larvae and pupae during early, middle and late stages was measured and recorded (Table 2). The data clearly reveal that the maximum cell size in each instar was found at the middle of the larval instar. At this stage the retraction of the epidermis has started. The cell size decreases at the time of moulting. The difference of the cell size between the two phases in the 2nd instar larvae was found to be 3.77×4.95 μm which reaches 30.25×16.00 μm in the 5th instar larvae.

The cell size in the pupae was found to be less than that of the last larval instar. The size remains almost constant upto the middle of the pupal stage. Later, 4 to 5 days before imaginal ecdysis, the cell size increases again thereafter, cell size reduces abruptly at the time of pupal-adult moulting (Table 2). The most active gland cells are considerably large in size and showing other features of the active glands.

Activity of the glands

The activity of the gland cells seems to start from the nucleus. In the beginning of the secretory activity, the nuclear volume gradually increases which is followed by the appearance of a large number of vacuoles. Simultaneously, the branching of nucleus also occurs. Afterward, the volume of the cytoplasm increases and the latter also contains vacuoles in it. This is the most active stage in the secretory cycle of the EG. The most active

Figs: 2. W. M. of the main cluster of ecdysial gland (EG) of the 5th instar larva × 265 ca; 3. W. M. of the ecdysial gland (EG) of 4-day 5th instar larva showing the filamentous structure (FS) and outer peripheral zone of the cells × 275 ca; 4. Ecdysial gland (EG) of a newly moulted 5th instar larva showing spherical nucleus (N) × 210 ca; 5. Ecdysial gland (EG) of a 5-day old 5th instar larva showing oval and spherical cells of the gland × 220 ca; 6. Ecdysial gland (EG) of 1-day old 5th instar larva showing increased nuclear (N) volume × 270 ca; 7. W. M. of ecdysial gland of 5th instar larva showing tracheal (TR) supply to the cells × 260 ca.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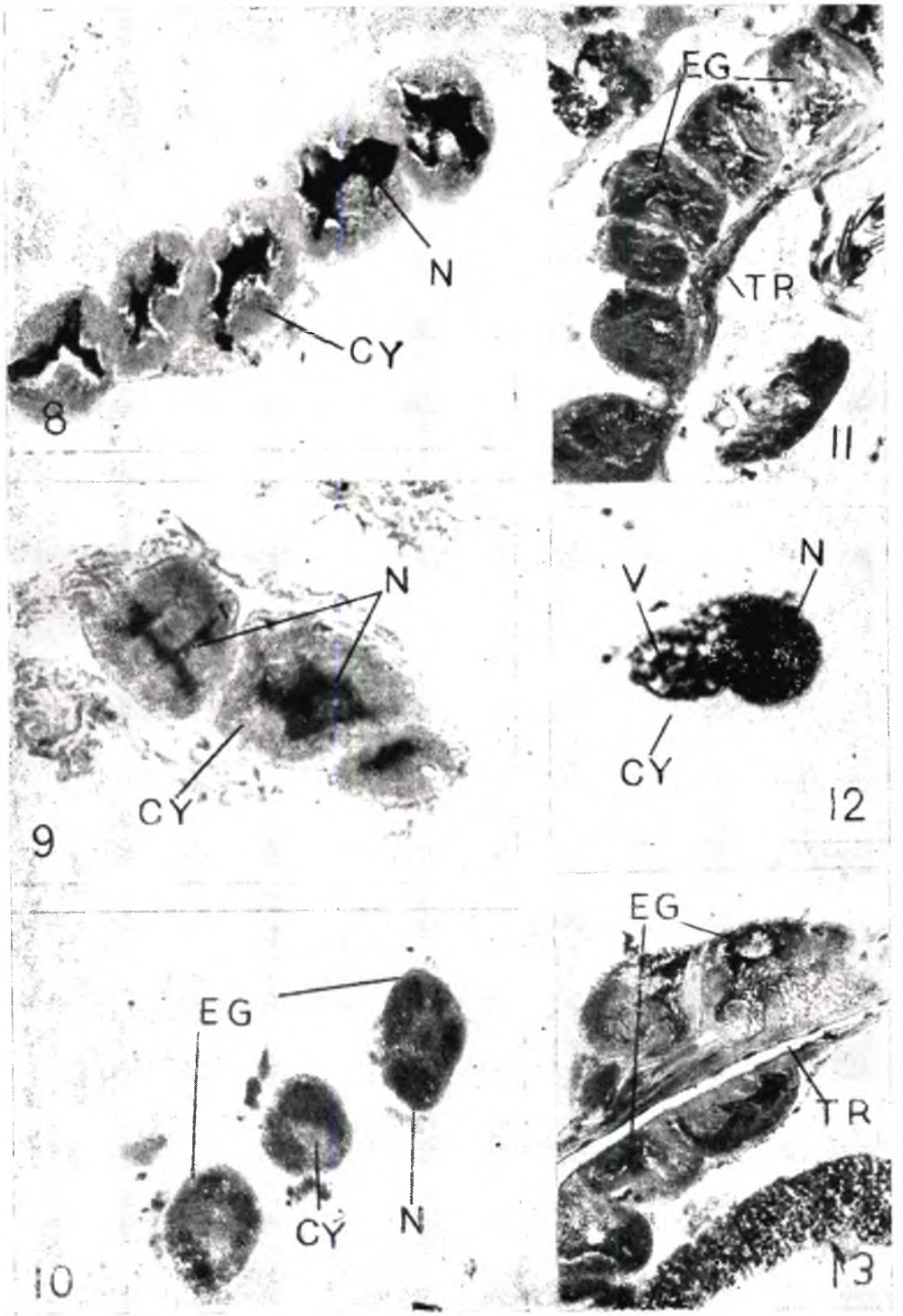
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glands have the maximum increase in the cell size in a particular instar. After that, the activity reduces gradually and was found to be minimum at the time of moulting or pupation. The EG showing their minimum activity are characterised by a small amount of cytoplasm devoid of vacuoles and a few small nuclear branches if any. Decrease in size of EG cells have also been clearly observed at the minimum stage of activity.

Activity in the 5th instar larvae

The 5th instar larvae feed voraciously for 4—5 days, rest for a day and then take 1 to 2 days for pupation. Observations made here are taken at a 24 hr interval throughout the 5th instar larva.

The size of the cells of a newly moulted larva was found to be minimum of the instar (Table 2). Volume of the nucleus was also found to be less which is almost spherical in appearance (Fig. 6). Most of the inner part of the cells is occupied by a large nucleus and a little amount of the cytoplasm. In 1-day old larvae, an increase in the volume of the nucleus and cell size was observed (Fig. 4). The volume of the cytoplasm remains almost the same as found in the cells of newly moulted individuals (Fig. 4). Further, the volume of the nucleus increases and small vacuoles were clearly seen in 2 day old larvae (Figs. 12, 25). The shape of the nucleus at this stage remains almost spherical (Fig. 25). On the 3rd day, branching of the nucleus starts which radiate in various directions in the cytoplasm (Fig. 14). The volume of the cytoplasm also increases and small vacuoles are observed at the periphery of the nucleus. The vacuoles of the nucleus disappeared at this stage (Fig. 14). On the 4th day, which appears to be the most active stage, a large amount of cytoplasm with numerous vacuoles and a fairly large nucleus was observed (Fig. 15). At this stage the cell size was recorded to be maximum (Table 2) and seemed to be directly correlated to the secretory activity. Brush borders are absent. On the 5th day, the vacuoles from the cytoplasm as well as the branching of the nucleus disappears (Figs. 8. 9) indicating the beginning of the inactivity of the glands. The inactive gland cells are characterised by their small size, cytoplasm devoid of vacuoles and reduced nuclear branching, if any (Fig. 8).

Prepupa

During pupation the branches of the nucleus become small which finally disappear leaving a smooth surfaced nucleus without vacuoles (Figs. 11, 17, 18). The nuclear inclusions were clearly observed at this stage (Fig. 19). The nuclear branches become small at the time of pupation. The EG of the 1 day old pre-pupae are almost identical in form to that of the other stages of prepupae (Fig. 22). The EG cells of the freshly moulted pupae contain large nucleus and a small amount

Figs: 8. Ecdysial gland (EG) of 5th instar larva (before moulting) showing the reduced nuclear branching × 270 ca; 9. Ecdysial gland (EG) of 5th instar larva (before moulting) cytoplasm (CY) without vacuoles × 210 ca; 10. Ecdysial gland (EG) of the late pupa (1-day before imaginal ecdysis) showing a little amount of cytoplasm (CY) × 425 ca; 11. Ecdysial gland (EG) of a prepupa showing reduced nuclear (N) branchings × 220 ca; 12. Ecdysial gland (EG) of 2-day old 5th instar larva showing vacuolation (V) in the nucleus (N) × 475 ca; 13. Ecdysial gland (EG) of 5th instar larvae (before moulting) showing tracheation (TR) to the gland cells × 230 ca.

TABLE 2. Average size (μm) of ecdysial gland cells of *A. janata* during post-embryonic development.

Stages	Develomental stages					Remarks
	Larval instars				Pupa	
	II	III	IV	V		
Early	17.23×32.05	22.75×30.25	37.75×37.50	55.75×49.00	75.75×53.25+	+ Prepupa
Middle	21.00×29.02	28.25×34.00	57.00×44.00	86.00×65.00	76.00×62.50	* 3—5 days before imaginal ecdysis
Late	20.00×29.50	26.75×25.2	47.00×43.75	78.50×70.00	79.15×70.00* 60.11×50.00**	** 1—2 days before imaginal ecdysis

of cytoplasm (Fig. 16). The nucleus shows poorly developed small branches but is totally devoid of vacuoles. Later the volume of the cytoplasm was found almost equal to that of the nucleus (Fig. 20). An increase in the volume of the nucleus has been observed in 3 to 4 day old pupae but the vacuoles were absent.

Mid pupa

At the mid pupal stage branching of the nucleus begins and the volume of the cytoplasm increases if compared to the nucleus. On the whole the cell size increases slightly if compared to that of the early pupal stage.

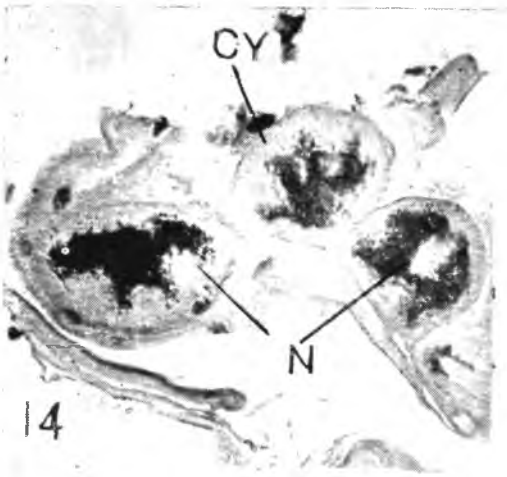
Late pupa

Before 3—4 day of the imaginal ecdysis, the gland cells were found to be quite active. A day before ecdysis, the glands were found to be inactive with a little amount of cytoplasm (Fig. 10). The nucleus has no branches and it gives an undulated appearance (Fig. 23). The gland cells were found smallest in size at this stage (Table 2). Glands degenerate at the time of moulting. The present observations have clearly shown that at the time of larval-pupal and pupal-adult ecdysis, there is a fundamental change in the morphology of the nucleus as well as in the volume of the cytoplasm. A minimum volume of the cytoplasm was observed in the later stages of the pupae (i.e., just before the moulting).

DISCUSSION

HERMAN & GILBERT (1966) and HERMAN (1967) have classified compact and diffused type of EGs in insects, and in *Hyalophora* (HERMAN & GILBERT, 1966) occurrence of diffused type of EGs have been reported. The EGs of *Achoea janata* are of intermediate type i.e., "compact cum diffused" type as found in *Amsacta*

Figs: 14. Ecdysial gland of 3 day old 5th instar larva showing branched nucleus (N) × 2700 ca; 15. Ecdysial gland of 4 day old 5th instar larva showing branched nucleus (N) and vacuoles (V) in the cytoplasm (CY) × 280 ca; 16. Ecdysial glands of a freshly moulted pupa showing small volume/cytoplasm (CY) and large nucleus (N) × 260 ca; 17. Ecdysial gland of prepupa showing the smooth nucleus (N) cytoplasm (CY) devoid of vacuole × 250 ca; 18. Ecdysial gland of 1-day old prepupa showing smooth nucleus × 210 ca; 19. The ecdysial glands of a prepupa showing the nuclear inclusions (NI) × 220 ca.



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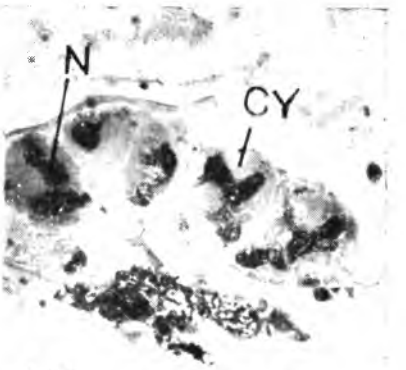

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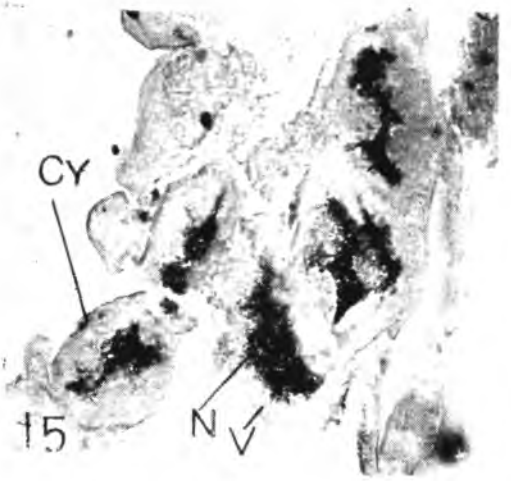

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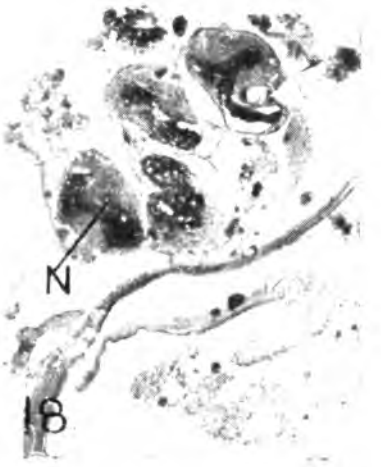

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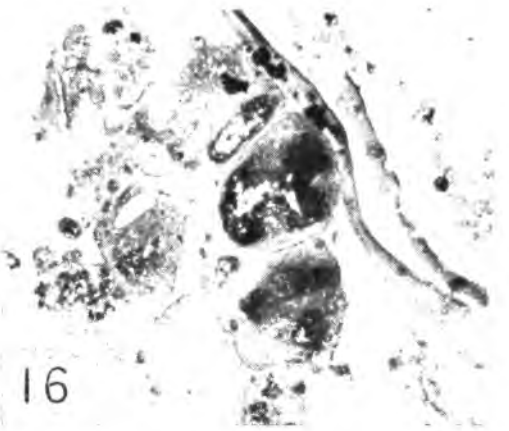

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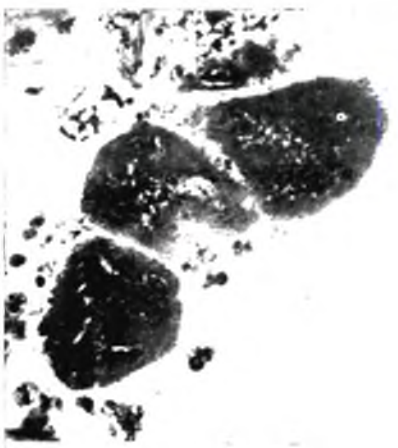

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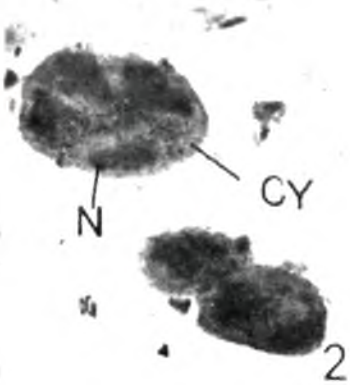

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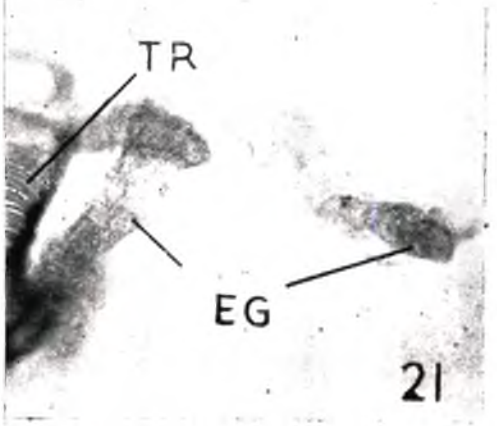

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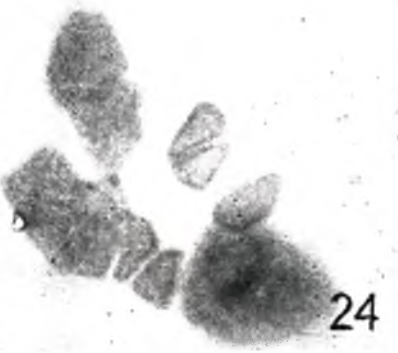

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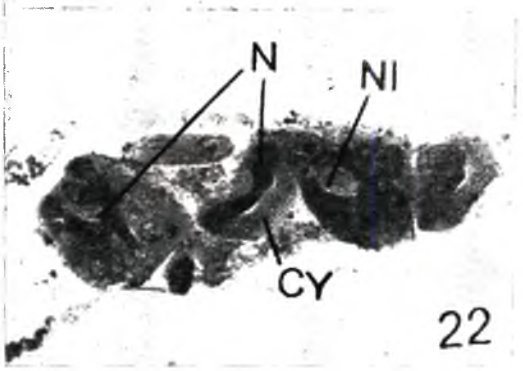

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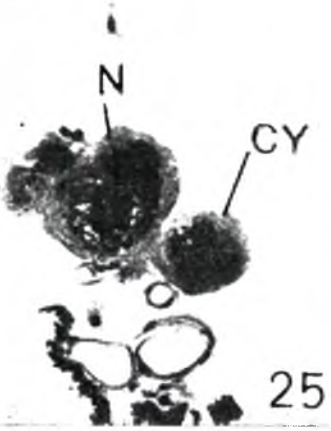

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(authors' unpublished observations). The main cluster of EG is placed just dorsal to the 1st thoracic spiracle from which branches radiate out in various directions.

Numerous workers have described the innervation of the EGs in lepidopteran insects. In *Hyalophora cecropia* HERMAN & GILBERT, 1966), *Diatrea grandeosella* (YIN & CHIPPENDALE, 1973), *Galleria mellonella* (GRANGER, 1978) and *Philosamia ricini* (SINGH & AWASTHI, 1980), the glands are innervated by the nerves of the thoracic ganglia.

In *Achoea janata* the glands are innervated by 4 pairs of nerves arising from the suboesophageal, prothoracic and mesothoracic ganglia and a medial-1 that arises from the posterior part of the prothoracic ganglion.

Considerable variations in the number of gland cells have been observed in different lepidopteran insects. ICHIKAWA *et al.* (1955) have reported 30 cells in the last instar larvae of *Ephestia cautella*. Each EG of *Prodenia litura* is composed of 51 to 62 cells (SEN & GANGRADE, 1977). Likewise there are about 194 cells in each gland of *Philosamia ricini* (SINGH & AWASTHI, 1980) and 92 cells in each gland of *Amsacta* (unpublished observations). In *Hyalophora cecropia*, each EG in male pupa is composed of an average of 242 cells and in female, 245 cells (HERMAN & GILBERT, 1966). The present study on *Achoea* has shown that the EGs of the last larval instar are composed of an average of 73 cells and maximum number of which is 76 in each gland. The observations made on the EG of Lepidoptera by various workers clearly indicate that there is no uniformity in the numbers of EG cells in the same insect and even the number of cells of one side differs from the other side.

Neurosecretory granules have been reported in the nerves to the glands in a number of insects (SLAMA *et al.*, 1974). Further MCDANIEL *et al.* (1976) have remarked that in the normal course of events the EGs are activated by neurosecretions released from the brain via the corpus cardiacum (CC). It has also been pointed out by a number of workers (WILLIAMS, 1952; SCHNEIDERMAN & GILBERT, 1964; WIGGLESWORTH, 1970) that the brain hormone stimulates the EGs to synthesize and secrete ecdysone into the blood which in turn promotes differentiation of adult tissues in the pupae. In *Achoea*, as in *Philosamia ricini* (SINGH & AWASTHI, 1980) the corpora allata (CA) and not the CC function as neurohaemal organ (NHO) and hence it is probable that the nerves emerging from the CA (in larval stages) might be innervating the EGs carrying BH, which in turn stimulates the glands as suggested by MCDANIEL *et al.* (1976).

From the data (Table 1) it is apparent that the gland cells increase at each successive stage starting from the 2nd instar to the 5th instar larvae. HERMAN & GILBERT (1966) and SINGH & AWASTHI

Figs: 20. Ecydsial gland of 2 to 3 day old pupa showing an increase in the volume of the nucleus (N) × 250 ca; 21. Ecdysial gland (EG) of 2nd instar larva showing compact gland cell × 260 ca; 22. Ecdysial gland of 1-day old prepupa showing nuclear inclusions (NI) and smooth nucleus (N) × 250 ca; 23. Ecdysial gland of late pupa (2 day before imaginal ecdysis) showing undulated nuclear body × 400 ca; 24. Ecdysial gland of 3-day old, 3rd instar larva showing triangular and/or rectangular cells × 260 ca; 25. Ecdysial gland of 2-day old 5th instar larva showing increased volume of nucleus (N) × 200 ca.

(1980) have also reported such a type of increment of the gland cells in *Hyalophora cecropia* and *Philosamia ricini* respectively. Not only at every successive stage but also in the individuals of the same age of the different sexes, variation in the number of gland cells was reported by HERMAN & GILBERT (1966). The gland cells differ in shape, size and secretory activity.

Active glands of *Achoea* are characterised by having large cells with branched nuclei and increased volume of the cytoplasm which is also provided with vacuoles. This stage occurs at about 4th day in the 5th instar larvae. During this period, the retraction of the epidermis has already started. Striated borders, though not clear in the *Achoea* have most frequently been observed in other lepidopterans when the gland shows maximum activity (ICHIKAWA *et al.*, 1955; SINGH, 1977; HERMAN & GILBERT, 1966; SINGH & AWASTHI, 1980). Maximal secretory activity in EGs of *Pieris* was observed 2 days after each moult in young larval instars (KAISER, 1949) and in *Hyalophora cecropia* at the first visible sign of epidermis retraction in each stage (HERMAN & GILBERT, 1966). The EGs in other lepidopterans also exhibit histological sign of high activity during similar periods with identical characters (KAISER, 1949; REHM, 1951; ICHIKAWA *et al.*, 1955).

A drastic change in the morphology of the nucleus as well as in the cytoplasm in the EGs at larval pupal and pupal-adult moult have been clearly observed. At the latter moult, the nuclear branches appear undulated. The volume of the cytoplasm was found to be lowest at the pupal-adult ecdysis. In *Hyalophora*, HERMAN & GILBERT (1966) have observed a change in nuclear morphology, cytoplasmic vacuolation and occurrence of striated borders at each moult i.e. larval-larval, larval-pupal and pupal-adult. Presumably these changes occur due to the presence of varying amounts of CAH at each moult, which at present is indicated by the glandular cyclicity of the CA (unpublished observations). But the possible involvement of the neurosecretory cells (NSCs) of the brain cannot be ignored since the activity of the CA depends upon the brain hormone. SCHNEIDERMAN & GILBERT (1964) have suggested that the CA and the NSCs of brain stimulate the EGs during the larval instars but only NSCs of brain influence the developing adults.

Acknowledgements: The authors are grateful to Prof. S. D. MISRA, Head, Gepartment of Zoology, University of Jodhpur, Jodhpur, for the facilities and to the authorities of UGC, New Delhi for sanctioning the research project No. F. 23-781/78 (SR II) dated 27-4-78 sanctioned to one of us (Dr. V. B. AWASTHI).

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BIOLOGY OF CASTOR HAIRY CATERPILLAR, *EUPROCTIS LUNATA* WALKER IN THE PUNJAB

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(Received 25 August 1980)

Studies on the biology of *Euproctis lunata* Walker were made at Ludhiana in the laboratory and in the field. The number of eggs laid by the fertilized females varied from 64 to 279 during August and from 27 tc 316 during November. The viability of eggs was much less (18.4%) in November. The incubation period in December was 10 to 22 days. The larval period varied from 12 to 121 days during different months. The first, second, third, fourth, fifth and sixth larval instars were completed in 7±0, 2.3 ± 0.6, 3.3 ± 0.6, 3 ± 0, 4.4±0.6 and 5±1.0 days, respectively in the month of October. The larval survival varied from 72 to 100%. Pupal development was completed in 9 to 20 days during different months.

Pre-oviposition and oviposition periods varied from 1 to 3 and 1 to 6 days, respectively. The mated females lived longer than the unmated ones. Three generations of the insect were completed in the laboratory from August to April. The sex ratio of adults (male : female) was 1 : 1.4 during August, 1 : 1 during November and 1 : 1.25 during April. The insect was active throughout the year on castor. Besides castor, it was also recorded feeding on plum, jujube, rose and *babul*. Two tachinid parasites, *Carcelia corvinoides* (Wulp.) and *Exorista larvarum* (L.) parasitized the larvae in the field.

(*Key words*: castor hairy caterpillar, incubation period, pre-oviposition period, oviposition period, sex ratio, tachinid parasite.)

INTRODUCTION

Castor hairy caterpillar, *Euproctis lunata* WALKER, is predominant among species of hairy caterpillars recorded on castor in Punjab (GREWAL & SINGH, 1979). The insect is active throughout the year. In addition to castor, it has also been reported feeding on some other hosts including jujube, barseem, lucerne and wheat (KUSHWAHA & BHARDWAJ, 1967). The larvae feed on the green portion of the leaves, leaving behind only the veins. After consuming soft foliage they have been observed feeding even on the bark of twigs and capsules.

Scanty information on the biology of this insect is available (HUSSAIN&LAL, 1918; MISRA, 1919;PRUTHI, 1941; NARAYANAN, 1959). Keeping in view the serious damage to the crop, present studies on the biology of this insect were undertaken at Ludhiana during 1977-78. The results are presented in this paper.

MATERIALS AND METHODS

Studies on the biology of *Euproctis lunata* were carried out in the laboratories as well as in the fields of the Department of Entomology, Punjab Agricultural University, Ludhiana. Advanced-stage larvae were collected from the field for this purpose and reared in the laboratory in the cylindrical glass jars (10×15 cm) on castor leaves. After pupation, the pupae were transferred in other glass jars having moist foam sheets at the bottom covered with filter paper. The adults

after emergence were transferred into the glass jars (10×15 cm) lined with rough white paper inside. Honey solution (2%) was provided with the help of cotton swabs kept hanging in the glass jars. The eggs were laid on rough paper, from where they were removed and kept on green food in Petri-dishes (10 cm diameter). The eggs were examined daily for hatching. Immediately after hatching, the larvae were released singly in the glass jars (5×10 cm) for studying their development and survival. Castor leaves were provided in the jars as food.

The pre-oviposition, oviposition, post-oviposition periods, fecundity and longevity were determined by keeping the paired moths in glass jars (10×15 cm) and transferring them daily to new jars. The observations on seasonal history of the insect were recorded by visiting the fields regularly.

RESULTS AND DISCUSSION

Eggs: In the laboratory, the eggs were laid in batches on the paper provided inside the jars. Under field condition the eggs were mostly found on the underside of the leaves, and less frequently on the upper surface. The eggs were pear shaped and the egg clusters were always covered with a thick light brown tuft of hairs. Number of eggs laid by a female varied from 64 to 279 with an average of 113.8±74.8 (n=10) during August when the average temperature and RH were 31.5°C and 73.3%, respectively. When the females were not paired with males they laid 10 to 106 unfertilized eggs per female with an average of 52.4± 31.6 eggs (n=10). During November, the number of eggs laid by fertilized females varied from 27 to 316 with an average of 191.2±96.7 (n=10). The viability of the eggs was 18.4%. The unfertilized females laid 37 to 98 with an average of 67.7±30.5 eggs (n=10). During this period average temperature was 24.0°C and RH 71.5%. ATWAL & SINGH (1972) reported the average number of eggs to be 167, 207 and 231 at 20, 25 and 30°C temperature, respectively.

The incubation period was 10 to 22 days (average 15.0±3.5 days) during the month of December when the average temperature was 16.0°C and RH 77.5%. ATWAL & SINGH (1972) reported the incubation period as 11. 26 and 7.23 days on 20 and 25°C temperature, respectively. During the present observation the incubation period was prolonged due to slightly low temperature in December.

Larvae: The larvae after hatching fed gregariously by scraping the leaf tissue. The larval period varied considerably during different months (Table 1). It was 13.5±1.3 days during July-August, 23.1±1.6 days during October and 114.2±3.8 days during December-March.

In the month of October the first, second, third, fourth, fifth and sixth larval instars were completed in 7±0, 2.3±0.6, 3.3±0.6, 3±0, 4.4±0.6, 5±1.0 days, respectively. The survival of the larvae was lowest (72%) during October and highest (100%) during July-August. Better survival in the months of July-August may be due to favourable temperature in these months (30.1 to 32.3°C). The temperature around 30°C is optimum for the development and survival of the larvae (ATWAL & SINGH, 1972).

Pupae: The pupation took place in dull brown cocoons. The pupae were obtect and yellowish brown when freshly formed turning deep brown before adult emergence. The pupal period also varied considerably during different months (Table 1). It was 10.8±0.8, 16.8±1.6 and 13.5±1.5 days during August, November and April, respectively. These observations confirm the findings of KUSHWAHA & BHARDWAJ (1967).

Adults: The adults are light brown in colour. A semilunar black spot is centrally located on the upper side of the forewings of both the sexes. The female is larger than the

TABLE 1. Development and survival of castor hairy caterpillar larvae and pupae in different months.

Period of observation	Cases studied	Period (days)		Percentage survival	Average temperature (°C)	Average R H (%)
		Range	Average			
			Larvae			
July—August	25	12-16	13.5±1.3	100	31.3	74.3
October	25	21-26	23.1±1.6	72	28.9	65.3
Dec.—March	20	108-121	114.9±3.8	95	16.7	72.5
			Pupae			
August	25	9-12	108±0.8	—*	31.5	73.3
November	20	15-20	16.8±1.6	—	24.0	71.5
April	20	10-16	13.6±1.5	—	30.0	66.1

*Pupal survival not studied.

male. Abdominal tip is round in female and pointed in male. The anal tuft of female is more conspicuous than male. The presence of the anal tuft in the males has also been reported by KUSHWAHA & BHARDWAJ (1967).

Mating took place soon after emergence. The pre-oviposition period was 1-2 days during August and 1-3 days in November. The oviposition period varied from 1-2 days in August and 1-6 days in November. The longevity of fertilized females was 2-3 days (average 2.1±0.4) in August (n=10) and 3-8 days (average 5.7±2.0) in November (n=10). Unfertilized females lived for 1-3 days (average 1.4±0.9) in August (n=10) and 4-6 days (average 5.0±1.4)in November (n=10). The longevity of mated males was 1-2 days (average 1.4±0.5) in August (n=10) and 5-7 days (average 6.2±0.8) in November (n=10). In case of unmated males this period was 5-8 days (average 6.5±2.1) during November (n=10). The adults were photopositive in behaviour.

The sex ratio of laboratory reared adults (male : female) was 1:1.4 during August, 1:1 during November and 1:1.25 during April.

Seasonal activity: The insect was found to be active throughout the year on castor. It was avilable in sufficient numbers, except in the month of May and first half of June when the population of the pest was extremely low. Low population of the larvae during this period may be due to poor survival because of very high temperature. The maximum daily temperature during this period ranged between 32.7 and 45.6°C and it went beyond 40°C on 37 days during this one and a half month. The first two instars of *E. lunata* have been reported to be sensitive to high temperature and the survival at 35°C and above is very low (ATWAL & SINGH, 1972). This fact was also verified during the present investigations. The larvae brought from the field in first week of May did not survive when kept at room temperature.

The population in the field again started increasing in the last week of June when the maximum daily temperature fell below 35°C and the mean relative humidity increased to above 70% due to pre-monsoon showers that occurred on 21st, 23rd and again on 25th of June. All the larval instars

were again available in July. Three generations of the insect were completed in the laboratory from August to April.

Host plants: Besides castor the insect was also recorded feeding on plum *(Prunus salicina* LINDL.), jujube *(Zizyphus mauritiana* LMK.), rose *(Rosa indica* (LINN.) and *babul (Acacia nilotica* (LINN.) Del.,). Earlier, KUSHWAHA & BHARDWAJ (1967) have reported this insect as a regular pest of jujube and castor and minor pest of berseem, lucerne and wheat from Madhya Pradesh.

Natural enemies: Two tachinid parasites, *Carcelia corvinoides* (WULP.) and *Evorista larvarum* (LINN.) were recorded parasitising the larvae in the field. The collective parasitization by these parasites was 10-15%. Both the parasites are reported for the first time from India. *Apanteles colemani* VIERECK and *A. euproctisiphagus* MUZAFFAR have been reported to parasitize the larvae of this insect in the field earlier (BHATNAGAR 1948; PANDEY, 1967).

Acknowledgements: Thanks are due to Director, Commonwealth Institute of Entomology, London for the identification of parasites and to Dr. A. S. SIDHU, the then Professor-Cum-Head, Department of Entomology for providing research facilities.

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EVALUATION OF FOLIAR SYSTEMIC INSECTICIDES AGAINST LEAF HOPPER, *AMRASCA DEVASTANS* (DIST.) ON POTATO CROP

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Field evaluation of six foliar systemic insecticides indicated that all of them viz., oxydemeton-methyl, phosphamidon, dimethoate, thiometon, monocrotophos and formothion at both i. e., 0.03 and 0.05% concentrations @ 1250 l of sprayable fluid/ha were quite effective in reducing and keeping down the population of leaf hopper, *Amrasca devastans* (Dist.) on potato crop. However, oxydemeton-methyl and phosphamidon each at 0.05% concentration proved to be the best treatments. Since both the concentrations were almost equally effective thus the use of lower concentration at 0.03% of these insecticides is suggested for the control of leaf hoppers to reduce the cost of plant protection inputs and also the pesticidal hazards involved in their application. First spraying should be given soon after noticing the leaf hoppers on crop and subsequent need-based sprayings may be given as soon as the population of leaf hoppers starts rising again.

(*Key words:* Oxydemeton-methyl (Metasystox 25 EC), phosphamidon (Dimecron 100 EC), dimethoate (Rogor 30 EC), thiometon (Ekatin 25 EC), monocrotophos (Nuvacron 40 EC), formothion (Anthio 25 EC), leaf hopper, *Amrasca devastans* (Dist.), systemic insecticides, mycoplasmal)

INTRODUCTION

Several species of leaf hoppers have been reported on potato crop from different regions of the country (SAXENA & RIZVI, 1974). Both the nymphs and adults suck sap from the mesophyll and cause direct damage to the potato foliage. Some of the leaf hoppers are vectors of mycoplasmal diseases viz., witch's broom, purple top roll and marginal flavescence in the hills and plateau regions (NAGAICH, 1974).

Out of the various species of leaf hoppers, *Amrasca devastans* (DIST.) is the most prevalent species found feeding on potato crop in Jullundur area (Punjab). They start appearing on autumn planted potato crop soon after the germination, probably because of their migration from cotton crops. Their population reaches the peak during October-November. In severe infestation, the typical symptoms of hopper burns are seen on damaged crop. With a view to protecting the potato crop from this pest, field experiments for evaluating the relative efficacy of foliar systemic insecticides were conducted at Central Potato Research Station, Jullundur (Punjab), during autumn 1978 and 1979. The findings are reported here.

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MATERIALS AND METHODS

Field experiments in randomised block design with triplicate treatments, were conducted using potato variety 'Kufri Chandramukhi' during autumn 1978 and 1979 at Central Potato Research Station, Jullundur (Punjab). Each plot (3.0×4.0m) had 5 rows containing 20 plants each. The plants were spaced 20 cm within the rows which were 60 cm apart. The agronomic practices recommended for the region were strictly followed in raising the crop.

Six foliar systemic insecticides viz., oxydemeton-methyl (Metasystox 25 EC), dimethoate (Rogor 30 EC), phosphamidon (Dimecron 100 EC), thiometon (Ekatin 25 EC), monocrotophos (Nuvacron 40 EC) and formothion (Anthio 25 EC) each at 0.03 and 0.05% concentrations were sprayed @ 1250 l /ha on the foliage of experimental plots. Control plots were sprayed with water. There were 13 treatments including control during both the years.

Insecticidal effect of foliar systemic insecticides was evaluated by recording the population of nymphs of leaf hopper, *A. devastans* 24 hr before undertaking the spray operations and then on 2, 5 and 10 days following the spray treatment from randomly selected 10 plants/plot during autumn 1978 and 1979. After square root transformation ($\sqrt{x+0.5}$), the data on the average number ef nymphs/plant, were analysed as suggested by SNEDECOR (1956).

RESULTS AND DISCUSSION

The data on the efficacy of foliar systemic insecticides in reducing and keeping down the population of leaf hopper, *A. devastans* recorded 24 hr before and after 2, 5 and 10 days of spray treatments from 10 randomly selected potato plants/plot during autumn, 1978 and 1979 are presented in Tables 1 and 2.

It is evident from the data recorded during autumn, 1978 (Table 1) that all the six foliar systemic insecticides viz., oxydemeton-methyl, phosphamidon, dimethoate, thiometon, formothion and monocrotophos at 0.03 and 0.05% concentrations are significantly superior over control in reducing and keeping down the population of leaf hoppers for about 10 days. However, oxydemeton-methyl and phosphamidon both at 0.05% concentration are the best treatments because the population of leaf hoppers recorded at different intervals following the spray operations was much less in these treatments as compared to others. Overall mean population (pooled from population data recorded after 2, 5 and 10 days of spraying) data also support this fact (Table 1).

In general, the data on the efficacy of foliar systemic insecticides against *A. devastans* during autumn 1979 reported in Table 2 are in agreement with those obtained for the preceding year. On the basis of overall mean population data, it is seen that all the six foliar systemic insecticides are statistically superior over control. Besides, phosphamidon at 0.05% concentration registered maximum protection. However, this is statistically at par with its lower concentration (0.03%) and also with oxydemeton-methyl 0.05 and 0.03%, dimethoate 0.05%, formothion 0.05% and monocrotophos 0.05% concentration (Table 2).

As regards the efficacy differences between 0.03 and 0 05% concentrations of these insecticides, it is revealed that except in a few cases, both the concentrations, in general, are equally effective in reducing *A. devastans* for about 10 days. Based on the effectiveness of these two concentrations it is advisable to use 0.03% concentration of the insecticides instead of higher concentration of 0.05%. This will not only reduce the cost of plant protection inputs but also the hazards involved in their use. MISRA & CHANDLA (1979) have reported oxydemeton-methyl/dimethoate sprays at 0.03% concentrations @ 1000—1200 l/ha

TABLE 1. Efficacy of some foliar systemic insecticides against leaf hopper, *Amrasca devastans* (DIST.), Autumn crop 1978.

Insecticide & formulation	Concentration %	Average* number of leaf hoppers/plant days after spray treatment				Mean
		24 hr before treatment	2	5	10	
Oxydemeton methyl (Metasystox 25 EC)	0.03	10.31 (107.30)	7.59 (57.80)	2.93 (8.83)	1.42 (1.84)	3.98
-do-	0.05	10.12 (103.23)	7.22 (52.43)	2.31 (5.53)	1.02 (0.78)	3.52
Dimethoate (Rogor 30 EC)	0.03	10.29 (106.50)	8.50 (72.73)	3.35 (11.38)	1.94 (3.42)	4.60
-do-	0.05	9.91 (98.67)	7.67 (59.03)	2.74 (8.03)	1.41 (1.88)	3.94
Thiometon (Ekatin 25 EC)	0.03	10.17 (103.84)	8.80 (77.72)	4.03 (16.42)	2.74 (7.40)	5.19
-do-	0.05	10.08 (101.68)	8.14 (66.53)	3.41 (11.77)	1.70 (2.47)	4.42
Formothion (Anthio 25 EC)	0.03	9.94 (99.33)	8.57 (73.92)	3.69 (13.78)	2.54 (6.13)	4.93
-do-	0.05	10.13 (104.03)	8.56 (73.47)	3.36 (11.48)	1.67 (2.33)	4.53
Monocrotophos (Nuvacron 40 EC	0.03	9.73 (95.67)	9.36 (88.60)	3.61 (13.50)	2.61 (6.33)	5.19
-do-	0.05	10.07 (102.43)	8.58 (74.12)	2.81 (8.10)	1.79 (2.88)	4.39
Phosphamidon (Dimecron 100 EC)	0.03	9.82 (98.00)	7.60 (57.97)	2.45 (6.12)	1.73 (2.60)	3.93
-do-	0.05	9.93 (98.90)	7.24 (52.63)	2.17 (5.17)	1.30 (1.50)	3.57
Control (Water spray)	—	10.14 (103.03)	10.22 (104.60)	10.26 (106.05)	9.93 (98.66)	10.14
SEM ±		0.40	0.24	0.30	0.30	0.54
C D (0.05)		N S	0.70	0.87	0.87	1.66

Figures in parentheses indicate retransformation in original units.

* Average of 10 plants each from three replications.

TABLE 2. Efficacy of some foliar systemic insecticides against leaf hopper, *Amrasca devastans* (DIST.), Autumn crop 1979.

Insecticide & formulation	Concentration %	Average* number of leaf hoppers/plant days after spray treatment				Mean
		24 hr before treatment	2	5	10	
Oxydemeton-methyl (Metasystox 25 EC)	0.03	6.58 (43.35)	3.41 (11.25)	1.67 (2.75)	1.30 (0.90)	2.13
-do-	0.05	6.29 (39.60)	2.18 (4.30)	1.06 (0.65)	0.87 (0.30)	1.37
Dimethoate (Rogor 30 EC)	0.03	6.00 (36.10)	4.06 (16.00)	1.89 (3.10)	1.31 (1.25)	2.42
-do-	0.05	6.24 (39.00)	2.86 (7.70)	1.39 (1.50)	0 98 (0.60)	1.74
Thiometon (Ekatin 25 EC)	0.03	6.32 (40.00)	3.98 (15.40)	2.69 (6.80)	1.36 (1.42)	2.68
-do-	0.05	6.74 (45.50)	3.17 (9.65)	2.42 (5.35)	1.35 (1.35)	2.31
Formothion (Anthio 25 EC)	0.03	6.93 (48.00)	4.60 (20.80)	3.67 (13.00)	1.67 (2.30)	3.31
-do-	0.05	6.57 (43.15)	2.96 (8.30)	1.56 (2.00)	1.32 (1.25)	1.95
Monocrotophos (Nuvacron 40 EC)	0.03	6.72 (45.25)	3.86 (14.45)	3.98 (15.40)	1.06 (0.78)	2.97
-do-	0.05	6.47 (41.90)	2.52 (5.00)	1.81 (2.95)	1.05 (0.80)	1.73
Phosphamidon (Dimecron 100 EC)	0.03	6.71 (45.00)	2.91 (8.00)	1.40 (1.50)	0.89 (0.35)	1.73
-do-	0.05	6.64 (44.20)	1.51 (2.15)	1.31 (1.25)	0.86 (0.25)	1.23
Control (Water spray)	—	6.53 (42.80)	6.96 (48.00)	7.31 (53.45)	7.08 (49.66)	7.12
SEM ±		0.17	0.20	0.24	0.14	0.33
C D (0.05)		NS	0.58	0.70	0.41	0.97

Figures in parentheses indicate retransformation in original units.

* Average of 10 plants each from three replications.

to be effective insecticides against leaf-hoppers in hilly tracts. They have further stated that weeds growing in irrigation channels and surrounding areas should also be sprayed with either of these foliar systemic insecticides for destroying the sheltering leaf-hoppers on them.

In conclusion, the potato crop can be protected effectively from leaf hopper, *A. devastans* by spraying with any of the six foliar systemic insecticides, preferably with phosphamidon or oxydemeton-methyl at 0.03% concentration of spray fluid @ 1250 l/ha. First spraying should be given soon after noticing the first appearance of leaf hoppers on the crop. Subsequent need-based sprayings may be followed, if their population is built up again on the crop.

Acknowledgements; Authors are grateful to Dr. B. B. NAGAICH, Director and Dr. A. P. SAXENA, Head, Entomology Division, Central potato Research Institute, Simla, for providing necessary facilities and for their valuable suggestions.

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PARASITES AND PREDATORS OF APHIDS (HOMOPTERA : APHIDIDAE) IN NORTH EAST INDIA. IV. TWELVE COLEOPTERAN AND TWO DIPTERAN PREDATORS OF APHIDS FROM SIKKIM

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This paper reports 12 coleopteran and 2 dipteran predators of aphids occurring in Sikkim. Among the coleopteran predators 2 species belong to the family Chrysomelidae and 10 species to the family Coccinellidae. Dipteran predators belong to family Syrphidae. Out of these, the 2 chrysomelid, 3 coccinellid and 1 dipteran predators are new records from India and 3 coccinellid and 1 dipteran predators are new records from Sikkim. Among the host species, 11 species have been found to be new ones for some of these predators in India.

(*Key words,* aphidophagous insects, new records)

The present communication is the report of some aphidophagous insects collected in Sikkim during the period 1977-78 along with aphid species. Determination of these predators reveals that they belong to the Coleoptera and Diptera. Out of 14 species, 12 belong to Coleoptera and 2 to Diptera. Coleopteran insects include 10 species of the family Coccinellidae and 2 species of the family Chrysomelidae. Both the dipteran predators belong to the Syrphidae. The two chrysomelid and 3 coccinellid species are new records from India as aphidophagous insects and 3 other coccinellid species are newly recorded from the state. Dipteran insects include 1 species as a new record from India and the other species as new record from the state. Besides, 11 aphid species are reported here as new hosts from India for 5 species of Coccinellidae and 1 species of Syrphidae. New records of aphidophagous insects for India have been denoted by * mark, those for the state by ** marks. New aphid hosts have been denoted by *** marks.

Material of the reported insects are in the collection of the Entomology Laboratory, Department of Zoology, Calcutta University.

Order COLEOPTERA

Family Chrysomelidae

1. ***Altica** sp.

Host: *Rhopalosiphum maidis* (Fitch) for *Hordeum vulgare*, 26. xii. 1977, Namchi (c 1666m): predatory stage : adult.

2. ***Chrysolina vishnu** (Hope)

Host : *Aphis kurosawai* (Takahashi) from *Artemisia* sp., 24. xi. 1977, Namchi (c 1666m): predatory stage adult

Family Coccinellidae

3. ***Aiolocaria** nr. **dodeocaspilota** (Hope)

Host : *Rhopalosiphum maidis* (Fitch) from *Hordeum vulgare*, 26. xii. 1977, Namchi (c 1666m); Predatory stage : adult: Sasaji (1967) reported *A. hexaspilota* as predator

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of *Eriosoma lanigera*, *Macrosiphum avenae* and aphids on citrus in Japan. From India, it is the first record of the genus and species as predator of aphids.

4. Ballia sp.

Host : *** *Brachycaudus helichrysi* (Kaltb.) from *Gynura angutosa*, 22. xi. 1977, Ranipul (**c** 1100m); predatory stage : adult.

5. Coccinella septempunctata (Linn.)

Hosts : *Acyrthosiphon pisum* (Harris) from *Pisum sativum*, 10. ii 1978, Namchi (**c** 1666m); *Aphis craccivora* Koch from *Vicia faba*, 27. xii. 1977, Namchi (**c** 1666m); *A. spiraecola* Patch from *Capsicum frutescens*, 4. i. 1977, 11. v. 1977, Gangtok (**c** 1675 m) *********Aulacorthum magnoliae* (Essig and Kuwana) from *Sechium edule*, 30. xi. 1977, Gangtok (**c** 1675m); *********Greenidea* (*Trichosiphum*) *formosana heeri* Raychaudhuri *et al.* from *Psidium guayava*, 29. xii. 1977, Gangtok (**c** 1675; *********Lachnus tropicalis* v. d. Goot from *Quercus* sp., 16. v. 1978, Namchi (**c** 1666m); *********Subovatomyzus leucosceptri* Basu from *Turnera* sp. 18. v. 1978, Pelling (**c** 2080m) predatory stage : grub and adult.

6. *Coelophora bisellata Muls.

Host : *Aphis craccivora* Koch from *Vicia faba*, 8. v. 1978, Gangtok (**c** 1675m); predatory stage : adult. Puttarudriah and Channa Basavana (1958) reported *C. bisellata* Muls. ab. *nudtpennis* Sic. from south India as predator of *A. gossypii* and *A. craccivora.*

7. Coelophora sp.

Host : *Aphis gossypii* complex from *Galinsuga parviflora*, 16. v. 1977, Namchi (**c** 1666m); predatory stage : adult.

8. **Cryptogonus quadriguttatus (Weismann)

Host : *Toxoptera aurantii* (B. D. Fonscolombe) from *Schima wallichii*, 8. v. 1978, Mangan (**c** 1500m); predatory stage : adult.

9. *Henosepilachna sp.

Host : *Rhopalosiphum maidis* (Fitch) from *Hordeum vulgare*, 26. xii. 1977, Namchi (**c** 1666m); predatory stage : adult. Hodek (1973) quotes El Khidir (1969) while reporting *Henosepilachana elaterii* as a pest of cucurbits mentions that the insect also feeds on aphids. In the present case this coccinellid is not known as a pest of any plant it may but that it is a casual feeder of *R. maidis* or some other aphids also.

10. **Oenopia kirbyi Muls.

Host : *********Rhopalosiphum maidis* (Fitch) from *Hordeum vulgare*, 26. xii. 1977, Namchi (**c** 1666m); predatory stage : grub and adult.

11. Oenopia nr. **quadripunctata** Kapur.

Hosts : *Aphis fabae* complex from an unidentified host, *********Toxoptera aurantii* (B. D. Fonscolombe) from *Schima wallichii*, 8. v. 1978, Mangan (**c** 1500m); predatory stage : grub and adult.

12. **Oenopia sauzeti Muls.

Hosts : *Capitophorus hippophaes javanicus* H. R.LAMBERS from *Polygonum orientale*, 20. xii. 1977, GANGTOK (**c** 1675m); *********Clethrobius dryobius* Chakrabarti and Raychaudhuri from *Prunus cerasus*, 26 xii. 1977, Namchi (**c** 1666m); *********Toxoptera aurantii* B. D. Fonscolombe) from *Schima wallichii*, 8. v. 1978, Mangan (**c** 1500m).

order DIPTERA

Family Syrphidae

13. **Melanostoma orientale Linnaeus.

Hosts : *********Melanaphis sacchari* (Zehntner) from *Saccharum officinarum*, 26. xii. 1977, Mangan (**e** 1500m)

14. *Epistrophe griseocinctus (Bruneti)

Hosts : *Rhopalosiphum maidis* (Fitch) from *Hordeum vulgare*, 28. xi. 1977, Mangan (**c** 1500m).

Acknowledgements: Thanks are due to ICAR, New Delhi and UGC, New Delhi for partly financing the works. Due [thanks are also due to Zoological Survey of India for comments on the identity on some of the predators.

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OBSERVATIONS ON THE POPULATION TRENDS OF ROSE APHIDS AND THEIR HYMENOPTERAN PARASITES IN KALIMPONG, WEST BENGAL (INDIA)

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(*Received 20 July 1980*)

Rose plants form an important section of ornamental flora in Kalimpong, West Bengal, India. *Macrosiphum rosae* (L.) and *M. (Sitobion) rosaeiformis* Das are the common aphids which infest rose plants in this part of India. This paper accounts for the observations on the population trends of these aphids on rose plants along with their hymenopteran parasites viz, *Aphidius rosae* Hal. and *Aphelinus* sp. conducted during the period November 1976 to June 1977.

(*Key words:* population trends of aphids, hymenopteran parasites)

INTRODUCTION

Rose is one of the most adored ornamental plants and extensively cultivated in Kalimpong, West Bengal mainly for propagational purpose. It is a good exchequer earner to the nursery men. Among the large number of insect pests, aphids form an important group as pests of roses in Kalimpong. Among the aphids infesting roses as reported by CHAKRABARTI & GHOSH (1970), *Macrosiphum rosae* (L.) and *M. (Sitobion) rosaeiformis* DAS have been found to be important ones. These two aphid species most often occur in association in the same colony. BASU & BANERJEE (1958) and DAVID (1975) also made similar observations. These insects, in spite of gaining considerable economic importance, hardly any work has been done on population density and effect of natural enemies like hymenopteran parasites. In this connection it may be stated that ATWAL & DHINGRA (1971) worked on the biology of *M. (S.) rosaeiformis*.

Rearing of the parasitised specimens *M. rosae and M. (S.) rosaeiformis* revealed that *Aphidius rosae* HAL. and *Apheiinus* sp. parasitises both the species at Kalimpong.

MATERIALS AND METHODS

Rose plants grown in homesteads in and around Kalimpong were taken as experimental plants since these did not receive any insecticidal treatment. For the studies on population of aphids and their parasitisation by hymenopteran parasites 10 plants were selected in an area within 3 km radius where the altitude varied between 1100 m and 1260 m. Counting was done *in situ* on the selected plants for total population of apterae and alatae and for mummified aphids (caused by parasitisation of hymenopteran parasites) at monthly intervals. For this purpose four branches of an individual plant were selected at random and counting was taken between 8 AM and 10 AM on the day of observation i. e., 25th day of each month. The observation was continued from November 1976 to June 1977. Some of the meteorological data of the period were recorded daily. Percentage of parasitisation has been calculated by the method of PIMENTAL & GREGOR as quoted by STARY (1970).

RESULTS AND DISCUSSION

These aphids infest the growing aerial parts of the plants which occasionally bore reproductive buds or even flowers.

TABLE 1. Observations on the population trends of aphids on rose plant, % of parasitism and records of some meterological data.

Months (1976—'77)	Total No. of aphids	% of apterae	% of alatae	% of parasitism	Temperature Max.	Temperature Min. (in Celsius)	Average relative humidity (%)	Average rainfall (mm)
November	152	88.16	11.84	9.21	19.57	15.0	85.6	105.6
December	50	56	44	4	18	12.02	83.90	000
January	57	77.19	22.81	5.26	13.47	8.17	80.04	016.8
February	111	84.68	15.32	7.20	16.45	11.78	81.16	016.8
March	134	88.50	12.50	11.94	19.01	12.70	82.17	000
April	175	92.43	7.57	26	22.57	16.33	84.70	56.2
May	107	97.12	2.88	28.03	18.72	10.53	89.93	126.2
June	45	95.55	4.45	24.44	20.03	12.40	95.62	329.7

The insects, being gregarious, form thick colonies on the infested twigs. This results sometimes in curling of leaves and diminuting the size of the leaves. The flower buds on the affected shoots also shrivel in certain cases.

From the data as presented in Table 1 it can be made out that the population of the aphids fluctuates remarkably through the period of observation when two peaks of incidence, once during April and the other during November, are noticed. The simple correlation of population with abiotic factors like maximum and minimum temperature, relative humidity percentage and rainfall, when worked out, (Table 2) revealed that the population was positively correlated with maximum temperature ($r = +0.61$) and percentage of relative humidity ($r = +0.51$) and negatively correlated with rainfall ($r = -0.28$) and with minimum temperature though positively correlated ($r = +0.13$), it was very slight. The simple correlation of population with other variables like number of apterous viviparous females and alate viviparous females of aphid in the colony and number of individuals parasitised by hymenopterous parasites it could be found that the population bear high positive correlation with apterous viviparous females ($r = +0.96$) and with parasites ($r = +0.48$) but the correlation was negative with alate viviparous females ($r = -0.38$).

Parasitisation by hymenopteran parasites was found to bear positive correlation with maximum temperature ($r = +0.34$), minimum temperature ($r = +0.16$), percentage of relative humidity ($r = +0.25$) and rainfall ($r = +0.09$). It is, however, apparent that though positively correlated with minimum temperature and rainfall, the relation is very feeble. It has already been mentioned that number of aphids parasitised bear a positive correlation with the size of population.

Rather high degree of correlation could be found between alate population and the variables like number parasitised, RH % and rainfall and also the population size. The simple correlation coefficients (r) of these variables with alate population are +0.44, —0.41—0.77 and —0.38 respectively.

TABLE 2. Simple correlation coefficient (r) of population and parasitism with different variables.

	Apterae population		Parasite	Max. temp.	Min. temp.	RH%	Rainfall
Population	−0.96	–	+0.48	+0.61	+0.13	−0.51	−0.28
Parasite	–	–	–	+0.34	+0.16	+0.25	+0.09
Alate	+0.048	−0.38	+0.44	−0.20	−0.21	−0.40	−0.77

With maximum and minimum temperatures these values were —0.20 and —0.21 respectively and with number of apterae it showed practically no relation (r = +0.04).

From the foregone account and from the data presented in Table 1 it emerges out that under the climatological conditions in which studies were taken up, the function of population growth of aphids is positively correlated with average maximum temperature and average relative humidity and bears negative correlation with total amount of precipitation. It has also been found that the population growth is directly dependent on the number of apterous viviparous female in the colony during any period of the year. Activity of parasites appears to be favoured by maximum temperature and average percentage of relative humidity. Such enhanced activity also leads to higher number of aphids parasitised under higher population of aphid as this eases the host finding by the parasites. Contrarily, however, it may be found that the percentage of parasitisation of aphids is higher under low aphid (host) population density condition during April (Table 1). This is a normal phenomenon as higher activity of adult parasites under high temperature condition leads to higher percentage of parasitisation even under low host density condition as has also been reported by SHUJA UDDIN (1975) for the aphid host *Macrosiphum (Sitobion)* sp. and it's aphidiid parasite *Aphidius uzbekistanicus* LUZH. Incidence of alate in the colony has been found to be negatively correlated with all the abiotic factors considered here. While higher precipitation affords a mortality factor for the alates and such precipitation also brings about higher atmospheric humidity leading to less production of alate morph. LAL (1952) mentioned that any condition that causes moisture stress to the individual of the aphid colony brings about enhanced formation of alate in the colony. Higher ambient humidity obviates such moisture stress and so less incidence of alate morph. The negative correlation with the size of population in aphid colony may appear intriguing as density of population has been considered to be one of the contributory factors to enhanced alate production (HILLE RIS LAMBERS, 1966). It may be that the size of population, as observed in the present investigation, is not high enough to initiate formation of higher proportion of alate and natality of apterous viviparous female is higher under the present sets of condition. The positive correlation of alate with number of aphids parasitised is indicative of a phenomenon that increased parasitisation leads to increased formation of alate morph stimulating a dispersive propitiousness to the individuals of the colony.

Acknowledgement:—Thanks are due to ICAR and UGC, New Delhi for partly financing the work.

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INCIDENCE OF SOME IMPORTANT INSECT PESTS ON RED GRAM (*CAJANUS CAJAN*) IN WEST BENGAL

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Six species of insects have been considered as important pests on *Cajanas cajan* in West Bengal. These include *Aphis craccivora* Koch, *A. gossypii* Glov., *Clavigralla gibbosa* Spin., *Cydia critica* Meyr., *Exelastes atomosa* W. and *Oxyrhachis tarandus* F. Their appearance on the crop and peak period of incidence showed some relation to the plant growth. *C. critica* appeared during August, attained peak of incidence in early September which gradually decreased to disappear by middle of November. The aphids appeared during early October attaining peak of incidence any time during November to January and lingered on the crop until its maturity. *C. gibbosa* and *O. tarandus* usually made their appearance simulataneously during early October, peak incidence of the former occurred during November to January while the latter was most abundant during December and both the species continued on the crop until maturity. Pod borers, of which *Exelastes atomosa* W, was more predominant usually initiated infestation from about middle of November, The maximum infestation was found during January. It, therefore, appeared that most of the important insect pests of red gram occurred during the reproductive stage of the crop which naturally caused irreparable damage to the crop.

(Key words: pests on red gram, *Cajanas cajan)*

INTRODUCTION

Red gram *(Cajanus cajan)* is cultivated in West Bengal in a rather neglected way and as a result very poor yield is obtained. Substantial increase of the yield can be obtained by rational plant protection measures against the pests of this important pulse crop. The very basic requirement for this is to know the pest pattern of the crop, particularly for those that pose major problem. Very little information on the pest pattern of this crop in West Bengal is available. It is worthwhile to mention here that NAIR (1975) recorded from all over India as many as 96 pests occurring on this crop and in recent times SINGH & SINGH (1978) reported about 27 insect pests along with their status and incidence pattern on this crop in Delhi. The report of PRAMANIK & BASU (1976) is the only one of two pests, *Eucosma critica* MEYR and *Oxyrhachis tarandus* F. on this crop from West Bengal. The present report is intended to highlight the activity of some important pests of red gram in West Bengal as has been observed at Kalyani.

MATERIALS AND METHODS

A plot of 10×20 m sandy loam soil was sown with red gram variety UPAS 120 on 26th July 1976 and 28 July 1978 at Kalyani. The seeds were sown in line 50 cm apart and the plants were thinned about 15 days later to maintain plant to plant distance of 20cm within the row. Usual cultivation practices were followed to raise the crop and harvesting was done during third week of February in both the years.

Ten plants were selected at random during the seedling stage of the crop and labelled for systematic observations at weekly intervals on

the incidence of the pests. Observation on the incidence of *Clavigralla gibbosa* SPIN. and *Oxyrhachis tarandus* F. were made by noting the actual number of these insects present on the selected plants. Incidence of *Cydia critica* MEYR. was recorded by counting the number of infested shoots of two selected primary branches on the selected plants and then the percentage of shoots infested was worked out from the total number of shoots of the selected primary branches. For aphids, the intensity of infestation was recorded as zero when there was no infestation, it was 1 for small colony, 2 for moderate colony, 3 for big colony and 4 for very big colonies almost covering the whole twig and then mean infestation index was worked out (MUKHOPADHYAY & GHOSH, 1979). Pod borer infestation was estimated by actual counting of damaged pods and percentage the total number of pods present on the plant. The observations were continued and were recorded from the seedling stage of the plant to about two weeks prior to harvesting crop.

RESULTS AND DISCUSSION

Of the 37 insect species occurring and feeding on *Cajanus cajan*, 6 species viz. *Aphis craccivora* KOCH, *A. gossypii* GLOV. *Clavigralla gibbosa* SPIN., *Cydia critica* MEYR., *Oxyrhachis tarandus* F. and *Exelastes atomosa* were found to be dominant.

Among these 6 species the first to appear on the crop was *C. critica*. Its incidence was evident by the damage symptoms of folding of the apical leaves along

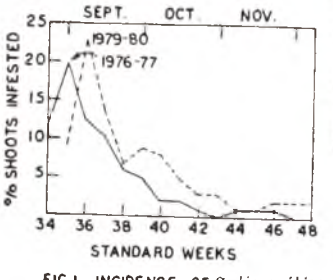

FIG.1. INCIDENCE OF *Cydia critica*

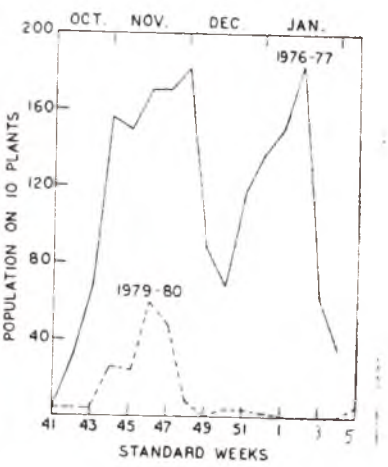

FIG 2. INCIDENCE OF *Clavigralla sp.*

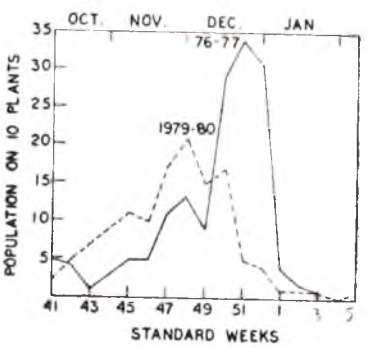

FIG.3. INCIDENCE OF *Oxyrhachis tarandas*

with the growing apex during August. Its infestation gradually increased to reach the maximum in early September. This was followed by a decline and disappearance by middle of November (Fig. 1). PRAMANIK & BASU (1967) found the peak of incidence of this pest during July-August in West Bengal and SINGH & SINGH (1978) in September-October in Delhi. This could probably be due to variation in time of sowing of the crop and difference in the prevailing climatic conditions. However, this pest of preflowering stage could not be found, in appreciable numbers, during the reproductive stage of the plant. It appears that the preponderance of this pest might have certain relation with the availability of infestable apical vegetative growth of the crop.

Aphis craccivora and *A. gossypii* have the same site of infestation on the plant which include all the tender aerial growths. Both the species of aphid was recorded simultaneously but the species which appeared earlier became dominant. In 1976 *Aphis craccivora* appeared during the second week of December but in 1979 it appeared in the third week of December and attained the peak incidence as late as in the second week of January 1980. Against this in 1976 *A. gossypii* appeared in the second week of November having highest incidence during first week of January 1977. In 1979 it appeared during second week of December and reached the highest incidence during first week of January 1980 (Fig. 2). Therefore, it may be concluded that the peak incidence of the two aphids occurred during December—January and both the species persisted on the plants as long as they remained green. SINGH & SINGH (1978) did not consider the aphids as major pests but in West Bengal these were found to be important.

O. tarandus occurred in a scattered manner from the vegetative stage of the crop, but become conspicuous by the middle of October i. e., during the flowering stage of the plants and attained abundance in December in 1976 and in the last week of November in 1979. In both the years, this insect persisted on the plant until about the time of harvest (Fig. 3). The peak incidence of this insect occurred some what late than it was observed by PRAMANIK & BASU (1967) but it was more or less the

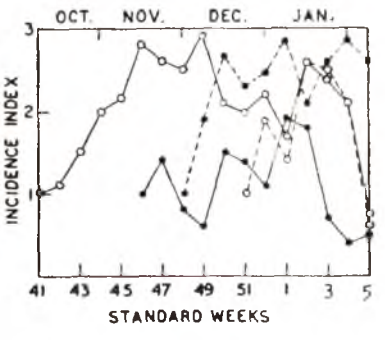

FIG. 4. INCIDENCE OF APHIDS
[o—o *A. craccivora*, •—• *A. gossypii* for 1976-77, o---o *A. craccivora*, •----• *A. gossypii* for 1979-80.]

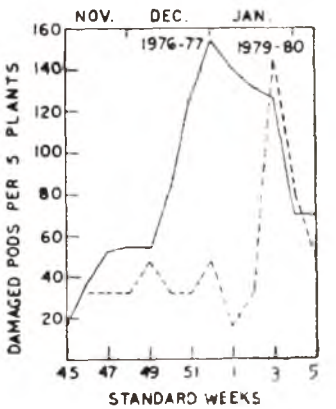

FIG. 5. INCIDENCE OF POD BORERS

same as was observed by SINGH & SINGH (1978).

In 1979 *C. gibbosa* initiated infestation during middle of October which was late by a week than in 1976. During 1976-77 the incidence of this insect rose abruptly to very high population in the last week of October, which persisted with some fluctuations up to the second week of January followed by a drastic decline. However, in 1979 the population did not reach so high but higher level of population was found in the middle of November. In both the years the pest persisted up to about the harvesting of the crop (Fig. 4). Incidence of this insect in Delhi extended from August to December (SINGH & SINGH, 1978) but the duration in West Bengal was rather short and the population was much higher at least during one year. However, the peak incidence was more or less same.

Pod borers formed complex of a few lepidopteran and a dipteran larvae of which *E. atomosa* was conspicuous. This was different to that found by SINGH & SINGH (1978) in Delhi where *Heliothis armigera* (HBN.) and *Melanagromyza obtusa* (MALLOCH) were reported as major pests. The damage by the borers became evident from the middle of November which reached its maximum during January but continued up to the harvesting of crop (Fig. 5). The peak incidence of the borers in Delhi was during November (SINGH & SINGH, 1978) depicting a difference in the phenology of the species of borers as well as the difference in the prevailing climatic conditions.

It has been revealed from the foregoing account that the pest situation and preponderance may vary with the variation in the ecological conditions of the localities as also of different years in the same area. The variation may also be caused by the difference in the sowing time of the crop. It has further been revealed that major damage to the crop is caused during its reporoductive stage when most of the major pests occur and flourish.

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COMBINED EFFECTS OF TEMPERATURE AND HUMIDITY ON THE HATCHING AND INCUBATION PERIOD OF EGGS OF SUGARCANE LEAFHOPPER *PYRILLA PERPUSILLA* WALKER

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The hatch rate of freshly laid eggs of *Pyrilla perpusilla* maintained at 30°C irrespective of humidity conditions was found to be 100% which however, could not extend beyond 50% at 25°C and 42.8% humidity. At 20°C and 40°C the eggs failed to hatch. The incubation period varied from 9.5 to 11 days and 6 to 8 days at 25°C and 30°C respectively under different humidity conditions.

(Key words: temperature, humidity, hatching, incubation, eggs, *Pyrilla perpusilla)*

INTRODUCTION

The sugarcane leafhopper *Pyrilla perpusilla* WALKER is a serious pest of sugarcane in India and it remains active throughout the year in northern sugarcane belt. Its activity, however, slackens at first during May, June when hot winds and high temperature prevail and again in December and January when there is steep fall in temperature (KALRA, 1973). The bionomics of the pest species was studied in field conditions by several workers (MISRA, 1917; RAHMAN & NATH, 1940; QUADRI & AZIZ, 1950 and BUTANI, 1964) who concluded that the incubation period of eggs is subject to variations during different seasons of the year. According to QUADRI & AZIZ, (1950) in July and August which are rainy months of the year, the incubation period ranges between six to ten days. This, however, varies between six and thirteen days during September and October. During the cold months of November and December the incubation period is longer and ranges between fifteen to eighteen days, while during the summer months of March, April, May and June the eggs take from ten to fifteen days for hatching.

SRINATH & PATEL (1968) studied separately the effect of temperature and humidity on the incubation period of *P. perpusilla* and reported that an increase in temperature up to a certain level decreased the incubation period and the optimum temperature for the shortest incubation period was found to be around 30±1.5°C. The eggs, however, failed to hatch at temperature below 20±1.2°C and above 35± 1.2°C. The authors, however, observed no significant difference in the incubation period of eggs with a change in relative humidity.

From the above data it is clear that practically no effort has been made to find out the combined effect of temperature and humidity on the hatching and incubation period of *P. perpusilla* eggs. The present investigations are therefore, undertaken with a view to find out the combined effect of

TABLE 1. Combined effects of temperature and humidity on the hatching and incubation period of eggs of *Pyrilla perpusilla* WALKER.

Temp. °C	Salts used	Humidity %	% hatching	incubation period in days
20	Ammonium hydrogen phosphate phosphate	93	0.0	—
20	Potassium bromide	84	0.0	—
20	Sodium chlorate	75	0.0	—
20	Sodium dichromate	52	0.0	—
20	Zinc nitrate	42	0.0	—
20	Chromium oxide	35	0.0	—
20	Potassium acetate	20	0.0	—
20	Zinc chloride	10	0.0	—
25	Ammonium hydrogen phosphate	93	0.0	—
25	Ammonium sulphate	81	5.0	11.0
25	Sodium chloride	75.7	15.0	9.5
25	Sodium bromide	57.7	20.0	10.0
25	Potassium carbonate	42.8	50.0	9.5
25	Magnesium chloride	33.0	25.0	10.0
25	Potassium acetate	22.5	10.0	10.0
25	Sodium hydroxide	7.0	10.0	8.0
30	Ammonium hydrogen phosphate	92.9	100.0	6.5
30	Ammonium sulphate	81.1	100.0	8.0
30	Sodium chromate	64.6	100.0	6.0
30	Sodium dichromate	54.2	100.0	8.0
30	Chromium oxide	44.6	100.0	7.0
30	Potassium fluoride	26.6	100.0	6.5
40	Ammonium chloride	79.5	0.0	—
40	Sodium chloride	74.7	0.0	—
40	Sodium chromate	61.8	0.0	—
40	Sodium dichromate	53.5	0.0	—
40	Chromium oxide	45.2	0.0	—
40	Sodium iodide	32.4	0.0	—
40	Potassium fluoride	22.8	0.0	—

both these ecologically important factors on the hatching and incubation period of the eggs of the pest.

MATERIALS AND METHODS

During the present studies freshly laid eggs of laboratory reared mated females were kept in soil inside small glass vials which were tied on the surface of museum jars provided with saturated salt solutions. The salt solutions were used for maintaining the desired relative humidity. The jars were properly sealed and kept in temperature controlled cabinet. Fifty eggs were kept at each combinations of temperature and humidity. The observations were taken daily on the hatching of eggs and the incubation period was also calculated. The data are presented in Table 1.

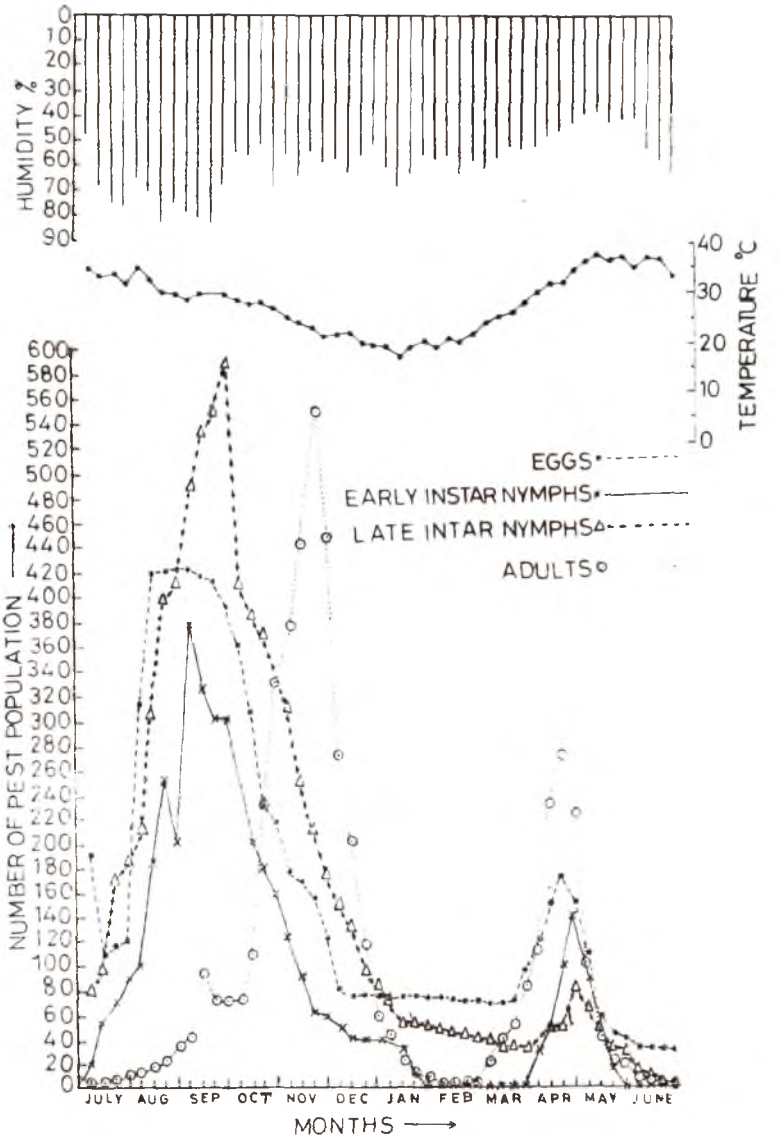

Fig. 1. Seasonal fluctuations in the popuations of *Pyrilla perpusilla.*

RESULTS

Table 1 clearly reveals that 30°C is the most favourable temperature for cent per cent hatching of eggs as all of them hatched at this temperature irrespective of any humidity condition. At 25°C the maximum hatch rate of 50% was obtained at 42.8% humidity and it decreased either by lowering or by raising the humidity level. The eggs, however, failed to hatch at 20°C and 40°C. The incubation period decreased with an increase in temperature from 25°C to 30°C. It varied from 6 to 8 days at 30°C at different humidities and from 9.5 to 11 days at 25°C with different humidity combinations.

DISCUSSION

These observations are in conformity with those of SRINATH & PATEL (1968) who discovered the optimum temperature around 30±1.5°C for shortest incubation period. They also noticed practically no significant differences in the incubation period of eggs with a change in humidity. In the present investigations the incubation period slightly changes at 25°C and 30°C with different combinations of humidity.

The present laboratory observations quite significantly resemble the data on eggs, early and late nymphal instars and adults collected from the field (Fig. 1). Early instar nymphs are at the peak in September at a temperature range of 28.5°C to 31°C and humidity 54% to 73% which resembles the laboratory observations revealing that 30°C is the most favourable temperature for the hatching of eggs irrespective of humidity conditions. The hatchability of eggs is suppressed from December to March where the temperature fluctuates between 17°C to 28°C and humidity 52% to 60% which is also obvious from laboratory studies that the percent egg hatch becomes too low at 25°C and 57.7% and 75.7% humidities. In field the eggs also failed to hatch in the month of June when the temperature fluctuates between 32.8°C to 36.6°C which may be further confirmed with the laboratory observations that eggs failed to hatch at higher temperature of 40°C.

The season starting from December to March and May, June is not much favourable to the fecundity as well as for the hatching of eggs as obvious from the figure that fecundity of adults is also decreased during these months. The fecundity of females is highest during the months of August to October which can be quoted as the most favourable season for egg laying.

The late instar nymphs are at its peak during September and October with a temperature range of 27°C to 31°C and show a suppression in extreme cold and hot seasons of the year. The adults are abundantly available in field at lower temperature range of 21.1°C to 25.2°C, however, its population show a considerable decline at higher temperature range in the months of May and June.

Acknowledgements:—The authors wish to express their gratitude to Dr. S. D. LOIWAL, Principal of the college and Dr. O. P. SAXENA for providing necessary research facilities. The author (M G) is also grateful to C S I R for providing Senior Research fellowship.

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NEW RECORDS OF APHIDS (HOMOPTERA : APHIDIDAE) FROM BHUTAN

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(Received 28 June 1980)

This paper reports for the first time 24 aphid species belonging to 21 genera from Bhutan.
(*Key words*: Aphids, new records from Bhutan)

First account of aphids occurring in Bhutan was provided by Ghosh, Basu and Raychaudhuri in 1971 when 15 species belonging to 12 genera and 2 subfamilies were reported. Subsequently there appeared a few other publications, viz., Ghosh (1972) and Dutta and Raychaudhuri (1977). Through these publications another 19 species under 13 genera and 2 subfamilies were added to the previous knowledge of aphid a fauna of Bhutan. Through the present work 24 species belonging to 21 genera and 6 subfamilies are reported for the first time from Bhutan.

The examples of the species are in the collection of Aphid Research Unit, Entomology Laboratory, Department of Zoology, Calcutta University.

Subfamily APHIDINAE
Tribe APHIDINA

Aphis kurosawai Takahashi
Material examined: 12 apterae from *Artemisia* sp. (Compositae), Chirang, 15. xii. 1976.

Aphis spiraecola Patch
Material examined: 2 apterae from *Mikania* sp. (Compositae), Sarbhang, 12. xii. 1976; 2 alatae from *Commelina* sp. (Commelinaceae), Sarbhang, 12. xii. 1976; 4 apterae from *Bidens pilosa* (Compositae), Bhure, 14. xii. 1976; 2 apterae from *Rosa* sp. (Rosaceae), Galyphug, 14. xii. 1976; 3 apterae from *Eupatorium odoratum* (Compositae), Bhure, 14. xii. 1976; 4 apterae from *Bougainvillea spectabilis* (Nyctaginaceae), Chirang, 15. xii. 1976; 2 apterae from *Chrysanthemum* sp. (Compositae) Chirang, 15. xii. 1976; 1 alata from *Ageratum conyzoides* (Compositae), Sandrup Jhankar, 5. xi. 1977; 2 alatae from *Mikania scandens* (Compositae), Sandrup Jhankar, 5. xi. 1967.

Hysteroneura setariae (Thomas)
Material examined: 5 apterae from *Triticum vulgare* (Gramineae), Bhure, 14. xii. 1976; 4 apterae from an indet. grass, Sandrup Jhankar, 5. xi. 1977.

Melanaphis sacchari (Zehntner)
Material examined: 4 apterae from *Zea mays* (Gramineae), Sandrup Jhankar, 5. xi. 1977.

Rhopalosiphum maidis (Fitch)
Material examined: 1 aptera from an indet. plant of Gramineae, Chirang, 15. xii. 1976; 4 apterae and 2 alatae from *Eleusine coracana* (Gramineae), Sandrup Jhankar, 5. xi. 1977.

Rhopalosiphum padi (Linnaeus)
Material examined: 2 apterae and 1 alata from an indet. plant of Gramineae, Sandrup Jhankar, 5. xi. 1977.

Rhopalosiphum rufiabdominalis (Sasaki)
Material examined: 2 apterae from an indet. plant of Gramineae, Sarbhang, 12. xii. 1976.

Tribe MACROSIPHINI

Akkala bengalensis (Basu)
Material examined: 4 apterae from *Polygonum* sp. (Polygonaceae), Sarbhang, 12. xii. 1976.

Capitophorus hippophaes mitegoni Eastop
Material examined: 2 apterae from *Polygonum barbatum* (Polygonaceae), Sandrup Jhankar. 5. xi. 1977; 4 apterae from *Polygonum* sp., Kunglong, 8. xi. 1977.

Cryptosiphum artimisiae Buckton
Material examined: 4 apterae from *Artemisia* sp. (Compositae), Kunglong, 8. xi. 1977.

Hyperomyzus carduellinus (Theobald)
Material examined: 3 apterae from *Gynura angutosa* (Compositae), Kunglong, 8. xi. 1977.

Macrosiphoniella sanborni (Gillette)
Material examined: 4 apterae from *Chrysanthemum* sp., Sandrup Jhankar, 5. xi. 1977

Neomyzus circumflexus (Buckton)
Material examined: 3 apterae from *Rumex nepalensis* (Polygonaceae), Kunglong, 8. xi. 1977.

Pentalonia nigronervosa (Coquerel)
Material examined: 3 apterae from *Musa* sp. (Musaceae), Sarbhang, 12. xii. 1976; Bhure, 14. xii. 1976

Shinjia pteridifoliae (Shinji)
Material examined: 1 alata from *Lycopersicum esculentum* (Solanaceae), Chirang, 15. xii. 1976.

Tuberocephalus sasakii (Matsumura)
Material examined: 4 apterae from *Artemisia* sp., Chirabg, 15. xii. 1976.

Tricaudatus polygoni (Narzikulov)
Material examined: 2 apterae from *Polygonum* sp., Chirang, 15. xii. 1976.

Subfamily CALLIPTERINAE

Taoia indica (Ghosh and Raychaudhuri)
Material examined: 4 apterae from *Alnus nepalensis* (Fagaceae), Kunglong, 8. xi. 1977.

Subfamily GREENIDEINAE

Greenidea (Trichosiphum) formosana heeri Raychaudhuri, Ghosh, Banerjee and Ghosh
Material examined: 5 apterae and 4 alatae from *Psidium guava* (Myrtaceae) Sarbhang, 12. xii. 1976; 3 apterae from *P. ganva*, Bhure, 14. xii. 1976.

Subfamily HORMAPHIDINAE

Paraoregma alexanderi (Takahashi)
Material examined: 6 apterae from *Bambusa* sp. (Gramineae), Kunglong, 8. xi. 1977.

Subfamily LACHNINAE

Tribe CINARINI

Cinara tujafilina (del Guercio)
Material examined: 4 apterae from *Cupressus* sp. (Cupressaceae), Kunglong, 8. xi. 1977.

Tribe LACHNINI

Nippolachnus bengalensis Basu and Hille Ris Lambers
Material examined: 8 apterae from *Pyrus communis* (Rosaceae), Kunglong, 8. xi. 1977.

Note: So far *N. bengalensis* was known to possess 9-14 secondary hairs on ultimate rostral segment (Basu and Hille Ris Lambers, 1968) but aforesaid specimens reveal that secondary hairs may be up to 16.

Subfamily PEMPHIGINAE

Tetraneua nigriabdominalis (Sasaki)
Material examined: 5 apterae and 2 alatae from an indet grass, Bhure, 14. xii. 1976; 1 alata from *Bougainvillea spectabilis* (Nyctaginaceae), Sandrup Jhankar, 5. xi. 1977.

Acknowledgements:—Thanks are due to ICAR, New Delhi in partly financing the work. Help received from the department of Agriculture

Govt, of Bhutan during collecting aphid samples from Bhutan and from the department of Botany, Calcutta University in the identification of the plants is also thankfully acknowledged.

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BIOLOGY OF *NIPPOLACHNUS PIRI* (MATSUMURA) INFESTING PEAR IN WEST BENGAL

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Nippolachnus piri (Matsumura) is one of the important aphid pests occurring on pear *(Pyrus communis)* in Kalimpong, West Bengal. It occurs throughout the year on pear but the infestation assumes serious proportion usually during July-October and it can scarsely be found during cooler months of the year. It is capable of completing about 19 generations in a year under laboratory conditions. It passes through four nymphal instars to become adult. All the stages of the life history are prolonged during the cooler period of the year. The nymphal duration ranges from 13 to 26 days and the adult longevity of the apterous morph varies from 10 to 34 days. The reproductive capacity also exhibits considerable variation, the capacity of laying young ones has been found to vary between 7 to 49 per apterous viviparous female.

INTRODUCTION

Nippolachnus piri (MATSUMURA) was described from Japan by MATSUMURA (1917). There it is reported to infest 8 species of plants belonging to three families (HIGUCHI & MIYAZAKI, 1969). While working with aphids of northeast India this aphid was found to infest only pear *(Pyrus communis)* in Kalimpong where it was found to cause substantial damage to the pear plants.

In Kalimpong this aphid was found to persist throughout the year on pear. However, the population was negligibly small during December-January when very small colonies of the aphid could be encountered.

MATERIALS AND METHODS

Studies on the life history were carried out on potted plants under laboratory conditions at Kalimpong. The plants were changed when necessary. Field collected apterous adults were released singly on each plant and observed for laying of young ones. The adults and excess of young ones, leaving only one freshly laid nymph on the plant, were removed. Fifteen such plants with freshly and more or less simultaneously laid nymphs formed a set for observations on the development and biology of each generation. Successive generations were raised from the first laid nymphs from the adults of the preceding generation. Daily records on the development biology, morphology and behavior were maintained.

To substantiate the laboratory studies, field observations on the population of the insect were also taken on pear grown in the vicinity of the laboratory. Records on the meteorological data were also maintained for the period of study.

RESULTS AND DISCUSSIONS

1. Host plant, nature of damage and seasonal history:

The aphid could be recorded only on pear in this region and as such it appeared to be host specific. However,

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HIGUCHI & MIYAZAKI (1969) reported as many as 8 host plants belonging to Betulaceae, Fagaceae and Rosaceae. Thus it appears that the aphid is host specific in this region.

With respect to colony formation a peculiar behaviour was exhibited. The individuals initiated colonisation at the petiolar portion of the under surface of the moderately old leaves. The aphid is gregarious. As the population increases the individuals restrict themselves along the midrib and in doing so their bodies remain perpendicular to the midrib with the head directed towards the midrib. The colony then gradually grows from the base of the leaves to the apex till the sides of the midrib are fully occupied by the closely apposed individuals. Non-availability of suitable feeding site on the midrib presses the individuals to move to other stout veins. The individuals appear to be sluggish and seldom leave their feeding site once they set themselves to feeding. However, in cases of overcrowding on a leaf the newly born nymphs move to other leaves. In such cases the nymphs usually move to the next available upper leaf. Though this insect was found to prefer moderately old leaves the copper coloured young leaves were also not spared during the period of excessive leaf shedding in winter when dormant buds were also found to be infested. After bud bursting and putting forth of young leaves the aphid colonised the young leaves because moderately old habitable leaves are not available during the spring.

In rare cases the very young leaves if infested may curl down due to draining out of plant sap. The frequently infested moderately old leaves though do not curl yet showed discoloration and ematiation, which finally dry and are shed. The mark of infestation, however, becomes evident by the dirty look of the infested plants due to growth of sooty mould on the leaves where honey dew secreted by the aphid was deposited. The growth of sooty mould on the leaves tells upon the general health of the plants as they interfere with the photosynthesis.

The peak period of infestation of the aphid was found to vary according to the situation of a locality. The population and frequency of occurrence gradually decreased from mid-October and became scarse from December to April. During bud bursting and appearance of new leaves with flowers, in January, small colonies of the aphid could be found on scattered plants. When the newly emerged copperish coloured leaves turned to green the population gradually increased to attain the peak incidence from the last week of July. During the following months up to October the infestation increased. It, therefore, appears that the population build up and spread of infestation follow the plant phenology. The scarcity of aphid population from October onwards can possibly be correlated with the change in plant physiology and lower temperature of the area.

2. Life history:

The adults bred by parthenogenetic viviparity. Pre-adult stages of this aphid pass through four nymphal instars. As no sexual form could be collected in the field at any time it appears that the aphid breeds by parthenogenetic viviparity under natural conditions also.

The freshly laid nymphs are pale cream with greenish tinge and light orangish head. The antennae of the first instar are almost always 4-segmented though rarely a faint additional segmentation may be discernible on segment III. The body

is elongate oval and 0.98—1.20mm in length, The rostrum is unusually long and extends upto about middle of abdomen. The first tarsal segment bears 4 long ventral hairs.

The second instar nymphs are light green with greenish patches over the dorsum and around the siphunculi and orange coloured head. Antennae are 5-segmented. The body measures about 1.28—1.50mm. It is similar to the first instar except that the first tarsal segment bears 5 long ventral

TABLE 1. Duration of different stages (days) and fecundity of *Nippolachnus piri.*

Date of onset of generation	Nymphal duration	Duration of different phases adults				Fecundity
		Pre reproductive	Reproductive	Post reproductive	Longevity	
1-6-1971	13	1—2 (1.50)	6—15 (11.50)	1—2 (1.70)	9—19 (15.50)	27—37 (32.25)
15-6-1971	13—14 (13.30)	10—14 (2.5)	2—3 (1.67)	15—20 (2.67)	15—20 (16.8)	23—24 (23.33)
4-7-1971	13—14 (13.67)	3	6—8 (7.00)	2	11—13 (12.0)	7—17 (12.0)
20-7-1971	13	2	8	1	11	16
5-8-1971	14	2	10	1	13	13
21-8-1971	13—15 (13.75)	2	22	1	25	34
8-9-1971	13—14 (13.88)	2	17	2	21	31
23-9-1971	13—15 (13.88)	2	17	2	21	27
9-10-1971	15—16 (15.17)	2	20	2—4 (3.00)	24—26 (25.00)	30
26-10-1971	17—20 (18.33)	4	14—25 (19.00)	1—4 (2.25)	21—34 (26.75)	17—31 (23.33)
17-11-1971	20—22 (21.24)					
22-12-1971	24—26 (25.00)					
23-1-1972	21					
15-2-1972	20	3	23.25 (24.50)	5—7 (6.00)	28.30 (29.00)	37—38 (37.33)
17-3-1972	15—16 (15.5)	3—4 (3.5)	19—26 (23.0)	1—6 (2.5)	23—33 (29.5)	41—46 (43.5)
5-4-1972	15					
20-4-1972	13—15 (13.8)	4	26	2	32	45
5-5-1972	13	3	21	6	30	42—49 (45.0)
21-5-1972	19	3	16	3	22	36

hairs in addition to a short peg-like structure.

In general appearence third instar nymphs are more or less similar to the second instar nymphs except that the antennae which are 6-segmented and the legs are dusky coloured instead of pale colour as in the previous instars. The body measures about 1.65—2.10mm.

The fourth instar nymphs exhibit substantial difference from the preceding instars with regard to morphological characters. Here the body colour is pale green with distinct irregular green patches dorso-laterally and around the siphunculi and the head is dusky. Rostrum extends up to the hind coxae. Otherwise the characters are similar to those of third instar nymph. The body measures about 2.10—2.65mm. The nymphs designed to become alate adults have wing pads on the dorso-lateral aspect of the thorax.

The adults are fairly big and elongate about 2.8 to 4mm. The colour is green and that of appendages brown. Head smooth with straight or convex frons having many long flagellate hairs. Eyes multi-faceted without any ocular tubercule. Antennae 6-segmented, short about 0.33 times as long as the body bearing long hairs and round secondary rhinaria in both apterae and alatae which is more numerous in the latter morph, processus terminalis short only about 0.20 times as long as the base of the last antennal segment. Rostrum extends slightly beyond hind coxae. Abdominal dorsum pale in apterae but with variably shaped sclerotic patches on the dorsum of alatae, body hairs numerous, long and flagellate. Siphunculi mamiform, sclerotic and hairy. Cauda broadly oval with many hairs. First tarsal segment with 9 long hairs ventrally. Forewing in alatae with *Rs* slightly curved, *M* simple or once branched.

The duraiton of different nymphal instars and different phases of the apterous adults vary considerably (Table 1). The total nymphal duration was found to vary between 13 and 26 days. The first instar and the fourth instar stages were found to have longer duration than the two intervening instars. The apterous viviparous females live for about 10 to 34 days. Preoviposition period and post reproductive periods vary from 2—5, 6—26 and 1—7 days respectively. One adult could lay 7 to 49 nymphs during its reproductive period. It may be mentioned here that the adult activity could not be studied in full during April, December and January due to large scale mortality. However, it could be inferred that the duration of different phases of the life of the insect usually shortened during the warmer months while it became longer during the cooler months.

This insect could complete 19 generations in a year under laboratory conditions. It was found that the adults were all apterous viviparous females. This is probably because the nymphs were raised singly on a host plant.

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Entomon, 1981, *Vol.* 6, *No.* 3, *pp* 233 *to* 238

PARASITES AND PREDATORS OF APHIDS (*HOMOPTERA : APHIDIDAE*) FROM INDIA—V. NEW RECORDS OF TWO APHIDIID PARASITES, NINE ARACHNID AND ONE DIPTERAN PREDATORS FROM INDIA

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(Received 20 July 1980)

This paper reports 2 aphidiids as parasites, 11 spiders, 12 coccinellids and 5 syrphids as predators of aphids from certain parts of India. 2 species of aphidiids, 9 species of spiders and 1 species of syrphid are new records for India. Apart from the above some aphids are recorded as new hosts for 1 spider species, 9 coccinellid species and 3 syrphid species under Indian conditions.

(Key words: parasites and predators of aphids)

This paper presents the results of extensive surveys in some parts of West Bengal, Sikkim, Uttar Pradesh and Himachal Pradesh for the exploration of aphids and their natural enemies.

Analysis of the collection of natural enemies reveals that it includes parasites and predators. Parasites belong to aphidiidae and predators are comprised of coccinellids, syrphids and spiders. In all, 2 species of Aphidiidae, 12 species of Coccinellidae, 5 species of Syrphidae and 11 species of spiders have been found to be natural enemies of 27 species of aphid hosts.

Review of the literature reveals that among parasites 2 species are new records for India. Of the predatory species, 9 species of spiders and 1 species of syrphid are newly reported from India. Besides, at least for India, 23 species of aphids are recorded as new hosts for some of the predators.

In the text new parasite and predator records for India have been denoted by *mark. New host records have been denoted by ** mark.

Examples of the natural enemies as well as the aphid hosts are in the collection of Entomology Laboratory, Department of Zoology, Calcutta University.

A. PARASITES

Family APHIDIIDAE

1. *Aphidius urticae group**

Host: *Pseudoacyrthosiphon holsti* (Takahashi) from *Rhododendron* sp., 18. v. 1979, Darjeeling (c 2000 m), West Bengal.

Outside India this species is known from Korea, Japan, Central Asia and Europe parasitising aphids of genera *Amphorophora*, *Acyrthosiphon*, *Macrosiphum Masonaphis*, *Metopolophium*, *Dactynotus* (Takada, 1976; Stary, 1976; Stary and Gonjales, 1978). It appears to be the first record of *Aphidius*

urticae parasitizing *Pseudoacyrthosiphon holsti* infesting *Rhododendron* sp. *Pseudoacyrthosiphon holsti* is restricted to South East Asia.

2. *Monochtonus nervosus (Haliday)

Host : Indet. aphid from indet. host, 31. x. 1978, Kufri (c 2700 m), Himachal Pradesh.

Outside India this species is known from Japan and Europe (Takada, 1968). In Europe it parasitizes *Impatientinum balsamines* (Kaltenbach).

B. PREDATORS

Order ARANEIDA

Family ARANEIDAE

1. Araneus sp.

Host : ** *Cinara* (*Lachniella*) *comata* Doncaster from *Pinus* sp., 24. x. 1979, Kufri (c 2700 m), Himachal Pradesh.

Raychaudhuri *et al.* (1978) reported *Araneus* sp. as aphidophagous in Sikkim and West Bengal feeding on some aphidine aphids.

Family CLUBIONIDAE

2. *Clubiona sp,

Host : *Myzus ornatus* Laing from indet. host, 28. x. 1979, Manali (c 2050 m), Himachal Pradesh.

Bradley and Hinks (1968) recorded *Culbiona mixta* as predaceous on aphids in Manitoba, Canada.

Family DICTYNIDAE

3. *Dictyna sp.

Host : *Macrosiphum rosae* (L.) from *Rosa* sp., 15. x. 1979; Jakhu (c 2400 m), Himachal Pradesh.

From Manitoba, Canada, 5 species of *Dictyna* have been reported by Bradley and Hinks (1968) as predaceous on Jackpine aphids.

Family OXYOPIDAE

4. *Oxyopes javanus Thorell

Host : *Lipaphis erysimi* (Kaltenbach) from *Brassica* sp., 5. v. 1979, Howrah, West Bengal.

Bradley and Hinks (1968) reported *Oxyopes* sp. as aphidophagous in Manitoba, Canada.

Family SALTICIDAE

5. *Salticus ranjitus Tikader

Host : *Lipaphis erysimi* (Kaltenbach) from *Brassica* sp., 23. ii. 1979, Howra, West Bengal.

In India it is the fourth record of an aphidophagous spider species under the family Salticidae. Raychaudhuri *et al.* (1978, 1979) reported *Rhene khandalaensis* Tikader and *Marpissa* sp. from West Bengal. Battu and Singh (1975) reported *Maevia himalaya* Tikader from the Punjab.

Family THERIDIIDAE

6. Theridion sp.

Hosts : ***Aphis gossypii* complex from *Zinnia* sp., 16. x. 1979, Solan (c 1450 m), Himachal Pradesh.

Earlier this genus has been reported by Raychaudhuri *et al.* (1978, 1979) from India. From Himachal Pradesh, the predator is newly reported.

Family THOMISIDAE

7. *Camaricus formosus Thorell

Host : *Lipaphis erysimi* (Kaltenbach) from *Brassica campestris*, 6. i. 1980; Howrah, West Bengal.

8. *Misumena sp.

Host : *Macrosiphum* (*Sitobion*) *rosaeiformis* Das from *Rosa* sp. 16. x. 1979, Manali (c 2050 m), Himachal Pradesh.

Bradley and Hinks (1968) recorded *Misumena vatia* (Clerk) as a predator of aphids infesting Jackpine in Manitoba, Canada.

9. *Philodromus sp.

Host : Indet. aphid from a pine plant, 29. x. 1979, Manali (c 2050 m), Himachal Pradesh.

Bradley and Hinks (1968) recorded 4 species of *Philodromus* feeding on Jackpine aphids in Manitoba, Canada.

10. *Thomisus pujilus Stoliczka

Host : *Aphis craccivora* Koch from *Dolichos lablab*, 26, i. 1980, Calcutta, West Bengal.

Family ULOBORIDAE

11. *Hiptita sp.

Host : *Macrosiphum* (*Sitobion*) *rosaeiformis* Das from *Rosa* sp., 7. xi. 1979, Simla (c 2000 m), Himachal Pradesh.

Bradley and Hinks (1968) recorded 43 species of spiders belonging to 11 families as predators of aphids infest ing Jackpine in Manitoba, Canada. Of these 6 genera belonging to 5 families are common with spider predators as reported here.

Order COLEOPTERA

Family COCCINELLIDAE

12. Ballia sp.

Hosts: ***Chaitophorus* sp. from *Populus* sp., 29. x. 1979, Manali (c 2000 m), Himachal Pradesh; ** *Rhopalosiphum maidis* (Fitch) from *Zea mays*, 14. v. 1979, Kalimpong (c 1100 m), West Bengal.

Verma and Chowdhuri (1975) reported *Ballia* sp. as predaceous on *Brachycaudus helichrysi* (Kltb.) in Himachal Pradesh. Agarwala and Raychaudhuri (in press) reported this species from Sikkim feeding on the same aphid host.

13. Coccinella septempunctata L.

Hosts : ***Aphis fabae* complex from *Rumex nepalensis*, 16. vi. 1979, Solan (c 1450 m), Himachal Pradesh; ** *Capitophorus* sp. from an indet. host, 25.x.1979, Mashobra (c 2149 m), Himachal Pradesh; ** *Dysaphis*? *emicis* (Mimeur) from an indet host., 22. vi 1979, Mashobra (c 2250 m), Himachal Pradesh: ***Hysteroneura setariae* (Thomas) from an indet. grass, 14. x. 1979, Solan (c 1450m), Himachal Pradesh; ***Pentalonia nigronervosa* Coquerel from *Musa* sp. 14. v. 1979, Kalimpong (c 1100 m), West Bengal; ***Pseudoacyrthosiphon holsti* (Takahashi) from *Rhododendron* sp., 18. v. 1979, Darjeeling (c 2100m), West Bengal.

In the area of survey this well known cosmopolitan predator of aphids has been found to be most prevalent among the aphidophagous insect and feed on a wide range of aphid hosts. Here six aphid species are recorded as new hosts of this predator. Previously the predator was known to feed on 21 species of aphids in India (Agarwala and Raychaudhuri, in press).

14. Coccinella transversalis F.

Hosts: ***Brevicoryne brassicae* (L.) from *Brassica* sp., 17. vi. 1979, Solan (c 1450m), Himachal Pradesh; ***Macrosiphum rosae* (L.) from *Rosa* sp. 16. x. 1979, Solan (c 1450m), Himachal Pradesh; ***Myzus persicae* (Sulzer) from *Raphanus sativus*, 23. x. 1979, Fagu (c 2510m), Himachal Pradesh.

Nath and Sen (1976) and Ghosh *et al.* (in press) recorded this predator from West Bengal feeding on *Lipaphis erysimi* (Kaltenbach) infesting mustard and *Aphis craccivora* Koch attacking *Dolichos lablab*.

15. Coelophora bissellata Mls.

Host: ***Rhopalosiphum maidis* (Fitch) from *Zea mays*, 14. v. 1979; Kalimpong, (c 1100m), West Bengal.

Agarwala and Raychaudhuri (1981 a) have mentioned this predator species as also its aphid hosts found in India.

16. Coelophora sexareata Mls.

Hosts: ***Pemphigus? napeus* (Buckton) from *Populus* sp., 23. vi. 1979, Simla (c 2000m), Himachal Pradesh; ***Rhopalosiphum maidis* (Fitch) from *Zea mays,* 14. v. 1979, Kalimpong (c1100m), West Bengal.

This predator species is new to Himachal Pradesh. Earlier Agarwala *et al.* (1980) reported the species from Manipur.

17. Cryptogonus quadriguttatus (Weid.)

Host: ***Rhopalosiphum maidis* (Fitch) from *Zea mays,* 14. v. 1979, Kalimpong, (c 1100m), West Bengal.

Raychaudhuri *et al.* (1978 and 1979) recorded this predator from West Bengal attacking some other aphid hosts.

18. Menochilus sexmaculatus (F.)

Hosts: ***Aphis ruborum longisetosus* Basu from? *Hibiscus esculentus,* Solan (c 1450m), Himachal Pradesh and an indet. host, 1. xi. 1979, Kulu (c 1200m), Himachal Pradesh; ***Macrosiphum rosae* (L.) from *Rosa* sp. 19. vi. 1979. Simla (c 2000m), Himachal Pradesh: ***Pemphigus? napaeus* (Buckton) from *Populus* sp., 23. vi. 1979, Simla (c 2000m), Himachal Pradesh.

Chowdhuri and Pal (1975) recorded this predator from Himachal Pradesh. Basheer (1958) Ray (1967), Rao (1969), Sharma (1973), Nath and Sen (1976) Raychadhuri *et al.* (1978), Joshi *et al.* (1979) and Ghosh *et al.* (in press) recorded the predator from other parts of India.

19. Oeneopia kirby Mls.

Hosts: ***Aphis gossypii* complex from an indet. host, 15. v. 1979, Gangtok (c 1675m), Sikkim; ***Coloradoa rufomaculata* (Wilson) from *Chrysanthemum* sp. 15. x. 1979, Solan (c 1450m), Himachal Pradesh.

20. Oenopia lutopusteulata Mls.

Hosts: ***Aphis gossypii* complex from an indet. host, 15. v. 1979, Gangtok (c 1675m), Sikkim; ***Rhopalosiphum maidis* (Fitch) from *Zea mays,* 14. v. 1979, Kalimpong (c 1100m), West Bengal.

This predator is a new record for Sikkim. Raychaudhuri *et al.* (1978, 1979) and Ghosh *et al.* (in press) and Agarwala *et al.* (1980) have recorded the predator from West Bengal and Manipur respectively.

21. Oenopia sauzeti Mls.

Hosts: ***Aphis gossypii* complex from *Rumex nepalensis,* Simla (c 2000m) Himachal Pradesh and an indet. host, 15. v. 1979, Gangtok (c 1675m), Sikkim; ***Aphis ruborum longisetosus* Basu from an indet. host, 1. xi. 1979, Kulu (c 1200m), Himachal Pradesh; ***Aphis spiraecola* Patch from an indet. host, 14. v. 1979, Darjeeling (c 2100 m), West Bengal; ***Brachycaudus (Thuleaphis)* sp. from *Rumex hastatus,* 5. xii. 1979, Nainital (c 1940 m), Uttar Pradesh; ***Diphorodon cannabis* (Passerini) from an indet. host, 27. x. 1979, Manali (c 2050m), Himachal Pradesh; ***Macrosiphum rosae* (L.) from *Rosa* sp., 16. x. 1979, Solan (c 1450m), Himachal Pradesh; ***Myzus persicae* (Sulzer) from an indet. host 16. x. 1979, Solan (c 1450m), Himachal Pradesh.

Rao (1969), Chowdhuri and Pal (1971), Raychaudhuri *et al.* (1978) and Agarwala *et al.* (1980) have recorded this predator on a number of aphid hosts from different parts of India.

22. Verania sp.

Hosts: ***Macrosiphum rosae* (L.) from *Rosa* sp., 19. vi. 1979, Simla (c 2000m), Himachal Pradesh; ** *Myzaphis rosarum* (Kaltenbach) from *Rosa* sp. 19. vi. 1979, Simala (c 2000m), Himachal Pradesh.

Agarwala *et al.* (1980) and Joshi *et al.* (1979) recorded this genus from Manipur and Andhra Pradesh respectively. For Himachal Pradesh this predator is a new record.

Order DIPTERA

Family SYRPHIDAE

Agarwala and Raychaudhuri (in press) showed the distribution and the host spectrum of the syrphid species given below except *Syrphus corollae* F., the latter being newly reported from India.

23. Episyrphus balteatus (De Geer)

Host : ***Macrosiphoniella sanborni* Gillette from *Chrysanthemum* sp. 22. x. 1979, Simla (c 2000m), Himachal Pradesh.

24. Ischiodon scutellaris F.

Host: ***Aphis verbasci* Schrank from an indet. host, Kulu (c 1200m), Himachal Pradesh.

25. Melanostoma orientale Wied.

Hosts: ***Macrosiphum (Sitobion) rosaeiformis* Das from *Rosa* sp., 6. xi. 1979, Sadhupul (c 1300m), Himachal Pradesh.

26. *Syrphus corollae F.

Hosts: *Brevicoryne brassicae* (L.) from *Raphanus sativus*, 27. x. 1979, Manali (c 2050m), Himachal Pradesh; *Myzus persicae* (Sulzer) from *Raphanus sativus*, 27. x. 1979, Manali (c 2050m), Himachal Pradesh.

27. Xanthogramma s.

Host : ***Hyperomyzus carduellinus* (Theoblad) from *Emilia sonchifolia* 14. x. 1979, Solan (c 1450m), Himachal Prdaesh.

Acknowledgements:—Heartfelt thanks are due to Dr. P. Stary of Czechoslovak Institute of Entomology, Prague for commenting on the aphid parasites and Zoological Survey of India for comments on the identity of some of the reported aphid predators. Thanks are also due to the University Grants Commission for financial assistance.

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AUTORADIOGRAPHIC STUDIES ON THE HAEMOLYMPH PROTEIN UPTAKE BY THE DEVELOPING OOCYTES OF *CRYNODES PEREGRINUS* F. (COLEOPTERA)

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(Received 14 June 1981)

The protein metabolism has been studied in Crynodes peregrinus by autoradiographic method using a mixture of ^{3}H-proline and ^{3}H-tyrosine as precursors. This study suggests the transport of haemolymph protein across the follicle epithelium and its incorporation into the yolk droplets at the oocyte cortex by pinocytosis in a phase specific manner. Whether there is also a follicle cell product that combines with the blood protein, could not be ascertained with certainty from this study.

(Key words:—blood protein, oocytes, follicle epithelium, autoradiography)

INTRODUCTION

The oocytes of insects attain prodigious volume increase during a short phase of their growth due especially to deposition of large amounts of protein yolk materials. The existing belief is that there is very little yolk protein synthesised within the egg cells, because light and electron microscopic studies showed a conspicuously poor development of the usual organelles associated with biosynthetically active secretory cells. Hence the proteid yolk is believed to be of exogenous origin either from the enveloping follicle epithelial cells and/or by incorporation of exogenous blood protein synthesised usually in the fat body.

Long ago, TELFER (1961) showed that in cecropia moths the yolk protein is immunologically identical with a particular fraction of haemolymph protein, which is present only in females or more abundantly in egg-laying females than in males. By combined vital staining and tracer techniques, it has been demonstrated that molecules of colloidal dimensions and labelled protein precursors injected into the haemocoel, both alike, move across the follicle epithelium and become incorporated into the yolk spheres at the oocyte cortex (RAMAMURTY, 1964; ANDERSON & TELFER, 1969; ENGELS, 1972; GIORGI & JACOB, 1977). The cytoarchitecture that facilitates this incorportion by pinocytosis has been investigated with electron microscopy in a number of insect species (KING, 1960; KESSEL & BEAMS, 1963; BIER & RAMAMURTY, 1964; ANDERSON, 1964; ROTH & PORTER, 1964; HOPKINS & KING, 1966; DELOOF & LAGASSE, 1970; HUEBNER & ANDERSON, 1972; CHIA & MORRISON, 1972; MAHOWALD, 1972; RAMAMURTY & ENGELS, 1977).

The organelles associated with the protein synthesising machinery such as mitochondria, rough endoplasmic reticulum and Golgi complexes are abundantly present in the follicle epithelial cell cytoplasm, but are absent in vitellogenic oocyte, as seen under the electron microscope. Though the possibility of follicle epithelial contribution of proteid yolk to the oocyte has been conceded by some workers (MELIUS

& TELFER, 1969; PETZELT & BIER, 1970; CHIA & MORRISON, 1972; HUEBNER *et al.*, 1975), it was actually demonstrated convincingly only in cecropia moth oocytes by ANDERSON & TELFER (1969). As a further confirmatory evidence in favour of this suggestion, BAST & TELFER (1976) have recently shown through an identification of labelled polypeptides by polyacrylamide gel electrophoresis, that a single labelled polypeptide is secreted by the follicle epithelium and that this is taken up by the oocytes, and packed into the yolk spheres along with the vitellogenin from haemolymph. The present study was undertaken to reveal the origin of proteid yolk in *Crynodes peregrinus*.

MATERIALS AND METHODS

The insect selected for the present investigation is *Crynodes peregrinus* FUESSLY. The insects were collected from the plants of *Calotropis giganticus* found in the campus of Banaras Hindu University, Varanasi, India. They could be easily maintained in the laboratory in jars by feeding them on fresh *Calotropis* leaves.

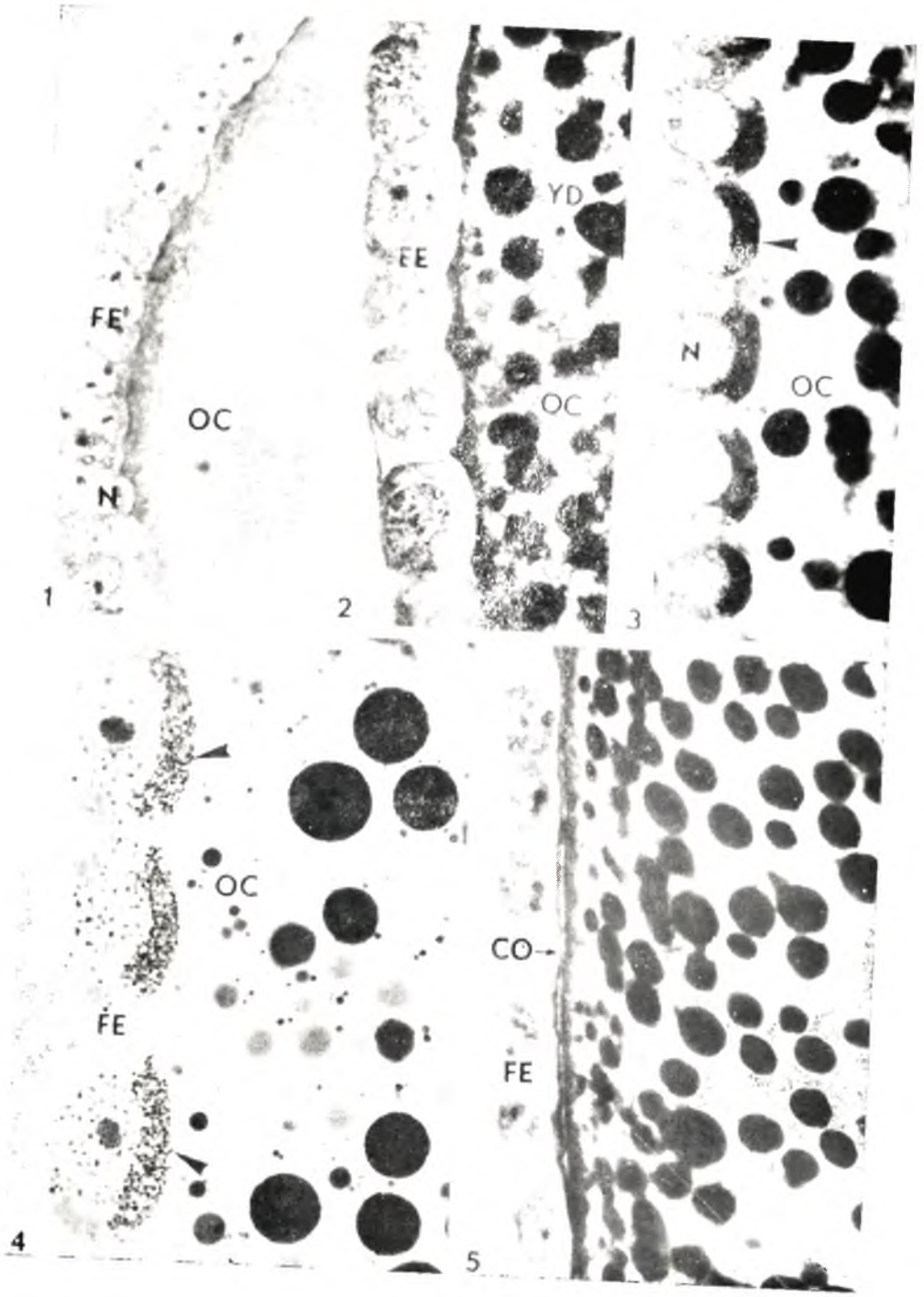
For histological studies the ovaries were fixed in Bouin's fixative and paraffin sections were stained with Heidenhain's iron haematoxylin-eosin. For semithin sections ovaries were fixed in 2.5% glutaraldehyde in 0.2 M sodium cacodylate buffer at pH 7.4 for 2 h at 4°C, and were postfixed in 1% osmium tetroxide for 1 h. Following dehydration materials were embedded in araldite through propylene oxide. Semithin sections of 0.5 to 1 μm were cut with glass knives on LKB-III ultratome, and stained in 1% methylene blue in 1% borax and studied with light microscope.

For autoradiographic studies a mixture of ^{3}H-proline and ^{3}H-tyrosine were used. These two amino acids were mixed in the ratio 1 : 1 and injected with glass needle into the haemocoel of the females (specific activity: ^{3}H-proline—1.5 Ci/m mole and ^{3}H-tyrosine—5.6 Ci/m mole and dosage—1 μCi/20 mg body weight). After varied incubation periods ranging from 15 min to 6 h, the ovaries were dissected and fixed in Carnoy's fluid. Parraffin sections were processed for autoradiography using Kodak AR—10 stripping film.

RESULTS

The vitellarium is composed of 3—4 developing oocytes in different stages of vitellogenesis, arranged in serial order. Stage I and II are previtellogenic, stage III is the main vitellogenic and stage IV is post-vitellogenic phase consisting of chorionated eggs. Stage II oocyte is comprised of largely yolk free ooplasma and a follicular envelope made up of close fitting columnar cells bearing oval shaped nuclei (Fig. 1). In early and mid stage III, which mark the onset of vitellogenesis, the follicle epithelial cells assume cubical outline and develop large intercellular spaces. The ooplasma is densely packed with yolk spheres of various dimensions (Fig. 2). In late stage III the apical border of the follicle cells shows sudden appearance of large number of secretory granules (Figs. 3, 4) which in all probability are chorion precursors, in as much as no trace of them is noticeable in early stage III and they disappear completely as the chorionogenesis advances in stage IV (Fig. 5).

Fig. 1. Section of stage II oocyte (OC) showing the columnar follicle epithelial cells (FE) with oval nuclei (N). Bouin/Haemalum-Eosin, × 375. Fig. 2. Mid stage III oocyte (OC) showing the cubical follicle epithelial cells (FE). Note the presence of large number of yolk droplets (YD) in the ooplasma. Bouin/Haemalum-Eosin, × 450. Fig. 3. Section of late stage III oocyte (OC) showing the accumulation of darkly stained granular masses (⟶) towards the apical border of the folloicle cells. Bouin/Haemalum-Eosin, × 450. Fig. 4. Semithin section of the oocyte (OC) showing the presence of numerous distinct granules (⟶) at the apical borders of follicle cells (FE). glutaraldehyde/osmium tetroxide/methylene blue, × 680. Fig. 5. Section of stage IV oocyte where the vitelline membrane and the chorion (CO) have begun to appear. Note the elliptical shape of the follicle epithelial cells (FE) and the accumulation of large yolk droplets in the oocyte. Bouin/haemalum-eosin, × 450.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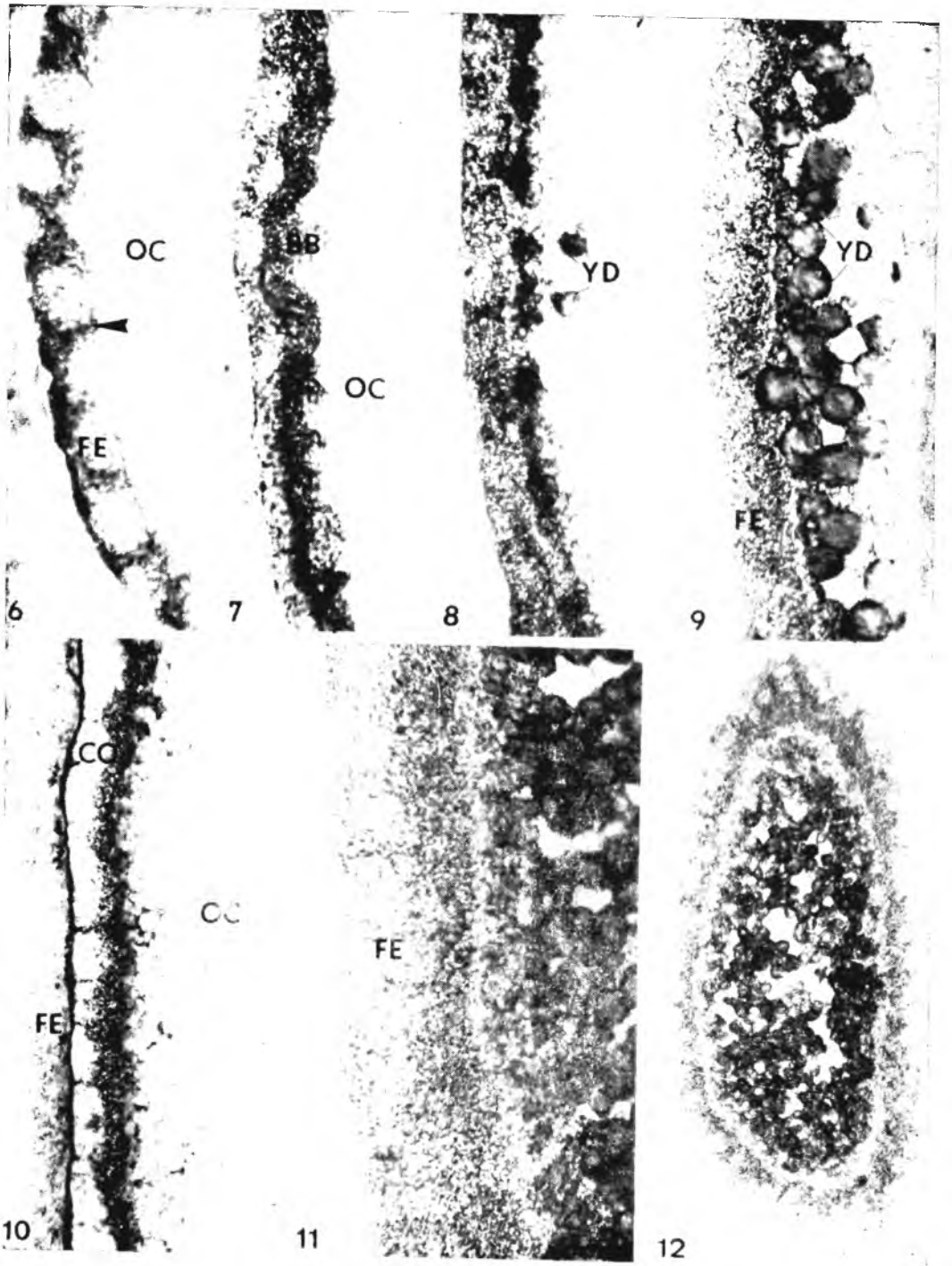
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Short incubation period of 30 min with the labelled amino acid mixture produces in the autoradiographs, a labelling of the cytoplasmic areas of the follicle epithelial cells in stage III oocytes. The cell nuclei are largely free from the label. The intercellular spaces, which tend to widen during this stage, are especially heavily labelled (Fig. 6). With 1 h incubation a strong radioactive border at the follicle epithelium-oocyte interface is visible (Fig. 7), although with this incubation time, the radioactivity is still not detectable in the deeper regions of the oocyte cortex. It is only with 2 h incubation, that radioactive yolk spheres pinching off from the oocyte surface becomes manifest. However, the labelled yolk spheres are found only at the periphery of the oocyte and do not move yet far inwards (Fig. 8). As the incubation is extended to 4 h the follicle epithelial layer radioactivity becomes diminished relatively and at the same time, the region of labelled yolk spheres extends further inwards (Fig. 9). With the same incubation time, the incorporation pattern in stage IV oocytes, however, presents a strikingly different picture (Fig. 10). The squamous follicle epithelium is practically unlabelled while the thin chorion which is in the process of its formation is strongly radioactive. Also the oocyte cortex, which becomes loosened and becomes separated from the chorion, is strongly radioactive, but the still deeper parts of the oocyte cortex, including the large yolk spheres, remain wholly unlabelled, apparently because the transport activity of the labelled molecules ceases, owing to the interpolation of the chorion (Fig. 10). Apart from this, as the vitellogenesis is fully accomplished by this stage, there is no evidence of large scale movement of the radioactive substances into the deeper parts of the oocyte. With the longest period of 6 h employed in this study, one finds practically the whole of the interior of the stage III oocyte is filled with labelled yolk spheres (Figs. 11, 12).

DISCUSSION

The existing literature on the origin of proteid yolk is indeed very vast. The centripetal origin of histologically detectable yolk spheres have prompted most of the workers to tacitly assume that the follicle epithelium synthesises the yolk protein and discharges into the oocyte cortex (BONHAG, 1959). This view was widely held till the publication of the classical work of TELFER (1961) in which he could demonstrate by serological methods, the identity of yolk protein with specific fractions of haemolymph protein in cecropia moths. Subsequently autoradiographic methods had been extensively employed to demonstrate that the bulk of yolk protein is exogenous in origin and arises by incorporation of

Figs. 6–12. Represent the patterns of incorporation obtained in the autaradiographs, after various incubation times ranging from 30 min, 1h, 2h, 4h, and 6h with a mixtnre of ^{3}H-proline and ^{3}H-tyrosine. All figs. relate to stage III except Fig. 10 which represents early stage IV after the commencement of chorionogenesis. Note the labelling of intercellular spaces (⟶) with 30 min incubation (Fig. 6), the brush border (BB) labelling with 1h (Fig. 7) and the peripheral yolk sphere (YD) labelling with 2h (Fig. 8). Fig. 9 shows the extent of the labelled and unlabelled part of the yolk system with unicubation. Figs. 11 & 12 illustrate how practically the whole yolk mass becomes strongly radioactive with 6h incubation. The two figures show the same at different magnifications. Fig. 10 shows how the interpolation of the chorion prevents the labelling of the yolk spheres even after 4h incubation during stage IV oocyte, compare this with Fig. 9, which is of mid stage III. CO-Chorion, FE-Follicle epithhlium, OC-Occyte, YD-Yolk droplet Figs. 6, 7, 8: × 320; Figs. 9, 10: × 450; Fig. 11, × 980; Fig. 12, × 80.

specific protein fraction from haemolymph. The ultrastructural adaptations of the follicle epithelium/oocyte interface (BIER & RAMAMURTY, 1964; ANDERSON, 1964; ROTH & PORTER, 1964; TELFER, 1965; HOPKINS & KING, 1966; DELOOF & LAGASSE, 1970; HUEBNER & ANDERSON, 1972; MAHOWALD, 1972; RAMAMURTY & ENGELS, 1977; HIGHNAM, 1977), during the vitellogenic phase of oocytes, that facilitates this protein uptake by pinocytosis have been elucidated with the help of electron microscope in variety of insect species. A number of experimental studies involving allatectomy, have shown that the synthesis of vitellogenic blood protein occurs in the fat bodies and is under the control of gonadotropic hormone (JH) of the corpus allatum (cf. ENGELMANN, 1970). Apart from this, JH is also known to regulate the DNA—dependent RNA synthesis in the follicle epithelial cells (SAHOTA, 1973). Further, the alteration of the follicle epithelial cells, such as the changes in the shape of the cells, development of conspicuous intercellular spaces that facilitate the inward migration of exogenous protein molecules (yolk precursors) is also stated to be under JH control (MASNER, 1968). More recent experimental and electron microscopic studies (ANDERSON & TELFER, 1969; CHIA & MORRISON, 1972; HUEBNER *et al.*, 1975a, b; BAST & TELFER, 1976) have brought convincing evidence to prove that the follicle epithelium, which is richly endowed with the organelles involved in the biosynthesis of macromolecules, synthesises a polypeptide, which together with the blood protein is built into the protein yolk spheres.

The present study with tritiated amino acids in *Crynodes*, has yielded autoradiographic patterns that are largely in agreement with those described by several previous authors (BIER, 1962; RAMAMURTY, 1964; STAY, 1965; KING & AGGARWAL, 1965; MELIUS & TELFER, 1969; ENGELS, 1972; GIORGI & JACOB, 1977; RAMAMURTY & ENGELS, 1977). The incorporation of the label into the yolk spheres at the oocyte cortex is phase specific, being confined only to stage III oocytes and is conspicuously absent in the preceding and subsequent stages.

In *Crynodes*, evidence is presented here for a strict phase specific synthesis of descrete protein granules during late stage III follicle cells, but the behaviour of these cytoplasmic inclusions suggest that they are definitely chorion precursors, because of their sudden appearance before chorionogenesis and their equally sudden disappearance after the accomplishment of this process. Whether any of these histologically detectable protein granules could make a contribution to yolk proteins, in the light of recent findings of BAST & TELFER (1976) could be clarified only by further experimental studies. Thus it seems that in *Crynodes*, proteid yolk is largely derived from haemolymph.

Acknowledgement:—The senior author thanks the CSIR, New Delhi for financial support for this work.

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BIOLOGY OF HELOPELTIS ANTONII SIGN. (HETEROPTERA : MIRIDAE) IN SRI LANKA

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(Received 20 July 1980)

The biology of *Helopeltis antonii* Sign. (Heteroptera : Miridae) the tea mosquito of cashew was studied in the field and laboratory. The life cycle is presented and the effect of mating, nutrition on egg production and longevity were investigated. The feeding habits and damage are discussed with distribution and abundance of *H, antonii*. A brief account of natural enemies of tea mosquito, identified in Sri Lanka is also mentioned.

*(Key words :—*biology, *Helopeltis antonii*, tea mosquito, cashew pest)

INTRODUCTION

Helopeltis antonii SIGN. known as tea mosquito, is a pest of increasing importance in cashew growing tracts of Sri Lanka. Its area of infestation has spread considerably in recent years due to widespread use of chemicals which have probably seriously affected the population of its natural enemies. Several workers (BASU CHAUDHURY, 1962; AMBIKA *et al.*, 1979) have identified *Helopeltis antonii* as one of the most important pests of cashew plantations. Some salient points about this pest with particular referance to the distribution, abundance and damage are summarized below.

Distribution:—A survey conducted in the cashew growing areas of Sri Lanka showed that tea mosquito is found in all the regions, but high concentration occurs mainly at the major cashew growing districts in Sri Lanka especially in the Mannar and Batticaloa districts. The pest seems to be found in areas where the cashew is growing under conditions optimum for cashew production including the localities where intensive cultivation and the best management practices are followed. It also occurs where the cashew is relatively young, where the Sri Lanka Cashew Corporation has encouraged the farmers to cultivate improved selections and use of approved agronomic practices.

Abundance:—*Helopeltis antonii* occurs throughout the year with marked population fluctuations. Data on the fluctuation in population density of tea mosquito howed that the build up of pest popusation commences from October—November, lsynchronizing with monsoon showers and emergence of new flushes (PILLAI *et al.*, 1979). It reaches its peak during the blossom period in January. The tea mosquito population was totally absent during the June—September period due to the

absence of succulent plant parts in cashew trees.

Effect of time of day:—Sampling in the morning (07.00 hr), in the afternoon (11.30 hr) and in the evening (16.00 hr) showed that significantly more insects occur in the morning than any other time of the day. It was observed that during the sunny hours of the day, the adults rest on underside of the cashew leaves and nuts possibly to avoid the direct sunlight.

Life cycle:—*Developmental stages*. There are five nymphal stages, and adult and an egg stage. Research on bio-ecological studies in India, revealed that it is completed on an average of 22.2 days at 28 ± 1°C, there being five nymphal instars occupying 1.3, 2.1, 3.5, 3.2, and 3.3 days in succession (AMBIKA *et al.*, 1979). Egg period lasts for 7.3 days and morphometrics of *Helopeltis* has been studied under laboratory conditions in India (AMBIKA *et al.*, 1979).

The highest nymphal mortality was recorded in the second instar stage (36% in laboratory and 48% in the field).

Effect of temperature:—The nymphs of *H. antonii* develop best at temparatures between 25°C and 30°C (mean developmental period of 22 days). There was no development at temparatures above 37°C and below 14°C.

Effect of alternate hosts:—Tea mosquito developes best on the tender branches and fruits of *Theobroma cacao* and *Psidium guava* (23 and 22 days respectively). Development of nymphs was delayed by 4—5 days when fed on tender leaves and branches of *Camellia sinensis*.

Effect of nymphal density:—Overcrowding in *H. antonii* was found not to affect the nymphal mortality and adult sizes. There was no effect on nymphal developmental period as well.

Effect of food age:—Tea mosquito was found to develop best when the nymphs are fed on cashew tender branches (average developmental period = 22 days), while tender cashew fruits delay nymphal development by about 2—3 days (average developmental period = 25 days). Ripened mature fruits cannot support the nymphs,

Oviposition and fecundity:—Pre-oviposition period for adult females averages 6 days. AMBIKA *et al.* (1979) stated that pre-oviposition and oviposition periods at 25 ± 0.5°C lasted for 4 and 6 days in India. The mean number of eggs laid by a single female was 39 out of which 30 hatched. The largest number of eggs per mass was 6 and the least was 2. There was an increase in egg totals deposited during first few days followed by a levelling off of egg production. Half of the eggs were laid in the first 8 days of oviposition. It was found that the older the insect the fewer the number of eggs/egg mass and longer the period between successive egg batches.

Virgin females lay fewer eggs than mated females but have longer pre-oviposition periods, oviposition periods and oviposition intervals. The number of eggs increases when a virgin female mates. On an average virgins lay 1—2 eggs/mass but on mating they lay 2—3 eggs.

Effect of food source:—When nymphs of *H. antonii* are fed on tender branches of cashew the ensuing adults lay more eggs (5 eggs/mass) than when fed on tender fruits (2 eggs/mass). Those fed on ripened fruits of cashew never laid eggs.

Oviposition activity:—Oviposition activity of adults of tea mosquito was at its maximum in the months of December and February and at its peak in January. These periods of heavy oviposition rates coincides with the blossoming season of cashew.

Effect of temperature on fertilization and oviposition:—Virgin adults lives longer than the mated ones. Studies on the influence of varying levels of constant temperatures on adult survival and progeny production in India, reveal that the temperature preferendum for fertilization and oviposition is around 25±0.5°C, while for embryonic and post embryonic development, the temperature preferendum was around 28±0.5°C. (AMBIKA *et al.*, 1979).

Male fertility:—Adult males become sexually mature 3 days after emergence. It was observed that one adult is capable of mating succesfully with upto 8—10 females to produce fertile eggs.

Mating behaviour:—Mating does not occur until at least 3 days after emergence and occur mainly in the mornings but is not restricted to that time of the day. The males mounts on the female and after the aedeagus is locked in position, the male and the female turn their ends and face away from each other. They remain in copula from 10 min to 2 hours. A female may mate upto 6—8 times during her adult life.

Egg laying behaviour:—Eggs are laid most often singly; if laid on a row it comprises between 2 and 5 eggs glued inside the substrate as well as along the sides of other eggs. Eggs in a batch are laid at 2—2.5 min interval. Most eggs are laid at night and in the field on tender branches and leaves but some may be laid on tender nuts as well.

Mode of hatching:—At eclosion, the pseudo-operculum is first opened at the periphery, then forced up by the head of the nymph through a series of pulsating movements of the body fluid. First the forelegs are released followed by the second pair, then the antennae, the hind legs and finally the abdomen. Eclosion of *H. antonii* takes approximately 10—12 min. Eggs dry out when exposed to relative humidities below 30% and temparatures above 37°C and below 15°C

Moulting:—At ecdysis, the old skin splits medially over the head and the thorax. The lateral halves of the dorsum are forced apart by the emerging nymph thereby exposing the thorax which at this time is in a humped position. Then by a rythmic series of movements, the emerging nymph forces the head free from the old skin followed by the forelegs, antennae, midlegs and finally the abdomen.

Both newly emerged nymphs and adults are very soft and pale brown in colour. They remain stationary for 2—6 min until the integument hardens. A newly emerged adult normally flies 1—2 days after the last moult and during this period it does not normally feed. Nymphs of all stages also stop feeding one day before and after moulting.

Sex ratio:—Sex ratio based on laboratory rearing was approximately 1:1 (76 males : 74 females). However in the field females predominates than the males (AMBIKA *et al.*, 1979)

Feeding behaviour

Feeding habits:—Before feeding the tea mosquito selects a suitable site on the tender branches by probing around the tree with the tip of the labium and the foretarsi. The stylets are slowly pierced through the epidermis of the branch and the contents are sucked. Observations showed that the foretarsi are only used as a support during the feeding periods.

Duration of feeding:—Feeding lasts from 10—30 min and is a continous process. There is an interval of about 10 min from the time the stylets are withdrawn

and another feeding site is selected. The length of the feeding period does not usually determine the number of branches damaged as one branch may be fed more than once. Individually an insect may feed for a very short period but may destroy more branches and fruits than the one which is exposed for a long period. This depends on the physiological state of the pest. However as an average the longer the feeding period, the more is the damage caused.

Frequency of feeding:—The number of branches and leaves destroyed by the different instars on daily basis increases as the insect grows older and adult males may destroy branches than adult females. Sex and mating have no effect on food consumption. Feeding is observed to be reduced a day or two before egg laying but increases a day or two after eggs are laid. Egg laying is delayed under low feeding conditions. Feeding is stopped before and after mating for certain duration depending on the instar involved.

Quantity of food consumed:—The second instar consumes the least food on daily basis while the third and fourth instars consume almost equal quantity. The older stages feed on relatively more sap than the younger instars (AMBIKA *et al.*, 1979).

Damage

Description of damage:—Both adults and nymphs pierce and suck the sap from the tender branches, shoot, leaves, floral branches, developing nuts and fruits. Studies in India on inflorescence blight (NAMBIAR *et al.*, 1973) have showed that the tea mosquito *Helopeltis antonii* is the primary causal agent and fungal species *Gloesporium mangiferae* and *Phomopsis anacardiae* were only secondary saprophytic colonizers. In Sri Lanka studies on blossom blight (RAJAPAKSE, 1980) revealed that *Helopeltis antonii* was the primary incitor and *Gloesporium mangiferae*, *Pestaliopsis* spp. *Botrydiplodia* spp were also associated with it.

Effect of environmental factors on population:—Different parameters of the physical environmental factors were correlated with the tea mosquito count. It was observed that apart from rainfall which causes about 35—45% nymphal mortality and 25% egg loss the rest, wind, sunshine, relative humidity and temperature had slight effect or indirect effect on tea mosquito population.

Natural enemies

Egg parasitism:—Investigations at Kondachchi showed that *Trichogramma* spp were parasitic on eggs of *Helopeltis antonii*, especially *Trichogramma minutum* RILE. (Hymenoptera : Trichrogramatidae) was found to be parasitic but the mean field parasitism was low during October and January.

Nymphal and adult parasitism:—Although *Euphorus helopeltidis* FERR. observed as a parasite from other plantations, dissection of field collected nymphs failed to record any parasites at Kondachchi.

Predator of tea mosquito:—*Crematogaster wrougtoni* FOREL (Hymenoptera : Formicidae) has been recorded for the first time as a predator of eggs and early instars of tea mosquito (AMBIKA *et al.*, 1979). Egg and nymphal predation is mainly by ants and spiders and in most instances restricted to the first three instars. *Oecophylla* spp and *Crematogaster* spp were found carrying eggs of *Helopeltis antonii* at Kondachchi.

Effect of insecticides on natural enemies:—Results from the field trials showed that the gamma BHC has an adverse effect on the % of both parasitism and predation of *Helopeltis antonii* in the field.

Acknowledgements:—The authors gratefully acknowledge the assistance rendered by the Technical Assistants of the Research Division of the Sri Lanka Cashew Corporation in collecting data and other information.

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FOUR NEW SPECIES OF *PHYLLOCOPTES* NALEPA (1889) (ERIOPHYIDAE : ACARINA) FROM SOUTH INDIA

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(*Received 20 July 1980*)

The paper describes four new species of *Phyllocoptes* Nalepa (1899). The mites are *P. aliyamagarensis* sp. nov., *P. indicae* sp. nov., *P. asperaevagrans* sp. nov., and *P. simplicifoliae* sp. nov. The mites are adequately figured.

(Key words:—new *Phyllocoptes* from South India)

The Present paper describes four species of *Phyllocoptes* Nalepa (1889) which are new to science.

The types and paratype slides are deposited in the Department of Agricultural Entomology Collection; Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore—641 003, India.

1. Phyllocoptes aliyamagarensis sp. nov. (Figs. 1 to 9)

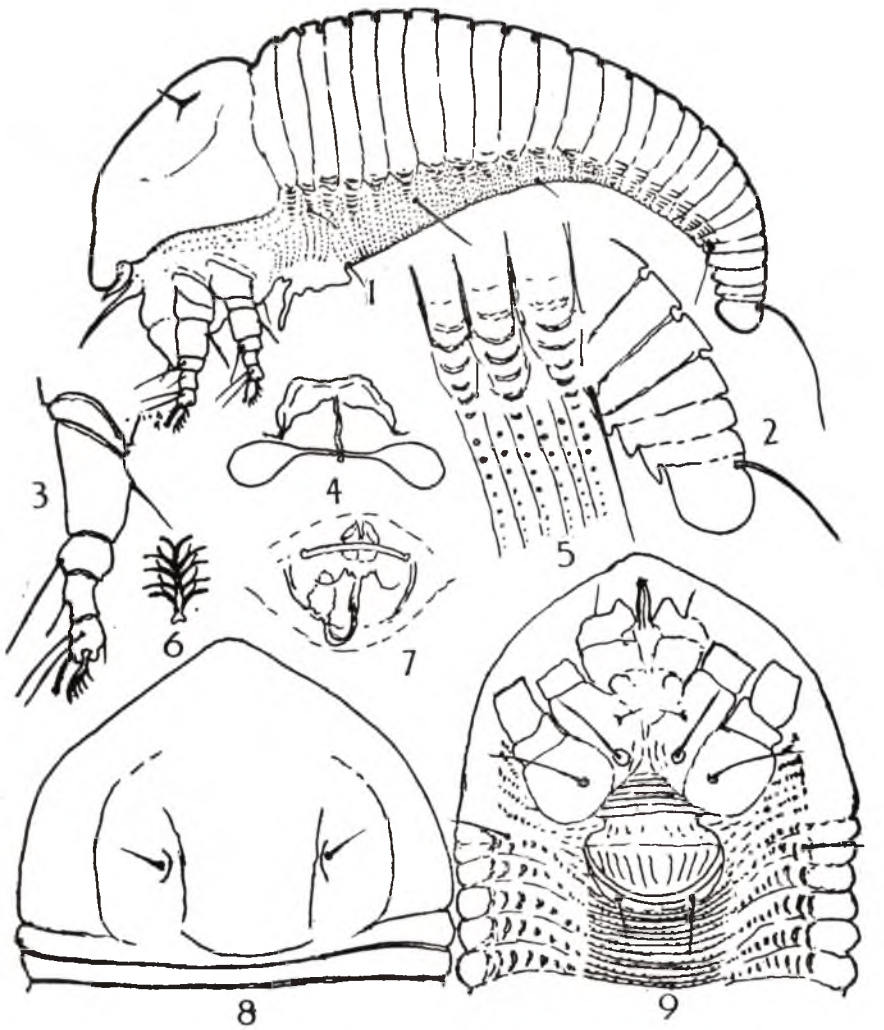
This mite resembles *Phyllocoptes aphrastus* Keifer (1940a) by the shield, but differentiated from its 5 rayed feather claw, shape of the internal apodeme apart from the measurements.

Female: 150—160 [1]long; 60 thick; rostrum 12 long; down curved; antapical seta 4 long; shield 45 wide, 55 long, a broad shield lobe overhanging rostrum base; median absent; admedians represented in the posterior half; submedian curved, placed beyond the dosal setae; sides of shield clear. Dorsal tubercles 20 apart, away from rear shield margin, dorsal sets 5 long pointing upward and forward. Foreleg 18 long; tibia 4 long; tibial seta 3 long at about the middle; tarsus 4 long, claw 4 long, slightly curved and knobbed at tip; feather claw 5 rayed. Hind leg 17 long; tibia 3 long; tarsus 4 long; claw 4 long, similar to foreclaw. Foreleg with the usual femoral, patellar, tibial and tarsal setae, while the hind leg with femoral, patellar and tarsal setae. Coxae with all three setiferous tubercles; coxal area clear. Coxal seta I, 6 long; seta II, 18 long; seta III, 25 long. Abdomen with about 25 broad, smooth tergites; 60 microtuberculate sternites, microtubercles becoming enlarged towards the sides of each ring. Lateral seta 5 long on ring 5; first ventral seta 10 long on ring 15; second ventral seta 5 long on ring 30; third ventral seta 20 long on ring 5 from behind caudal seta 18 long; accessory seta 0.5 long dot like. Female genitalia closely approximated to coxal base, 20 wide, 13 long; cover flap with 10—12 lines; genital seta 5 long.

Male: Not known.

Types:—A **holotype** slide and 5 **paratype** slide, all with 3 ♀♀ INDIA, TAMIL

[1]All measurements are in μm, unless otherwise specified.

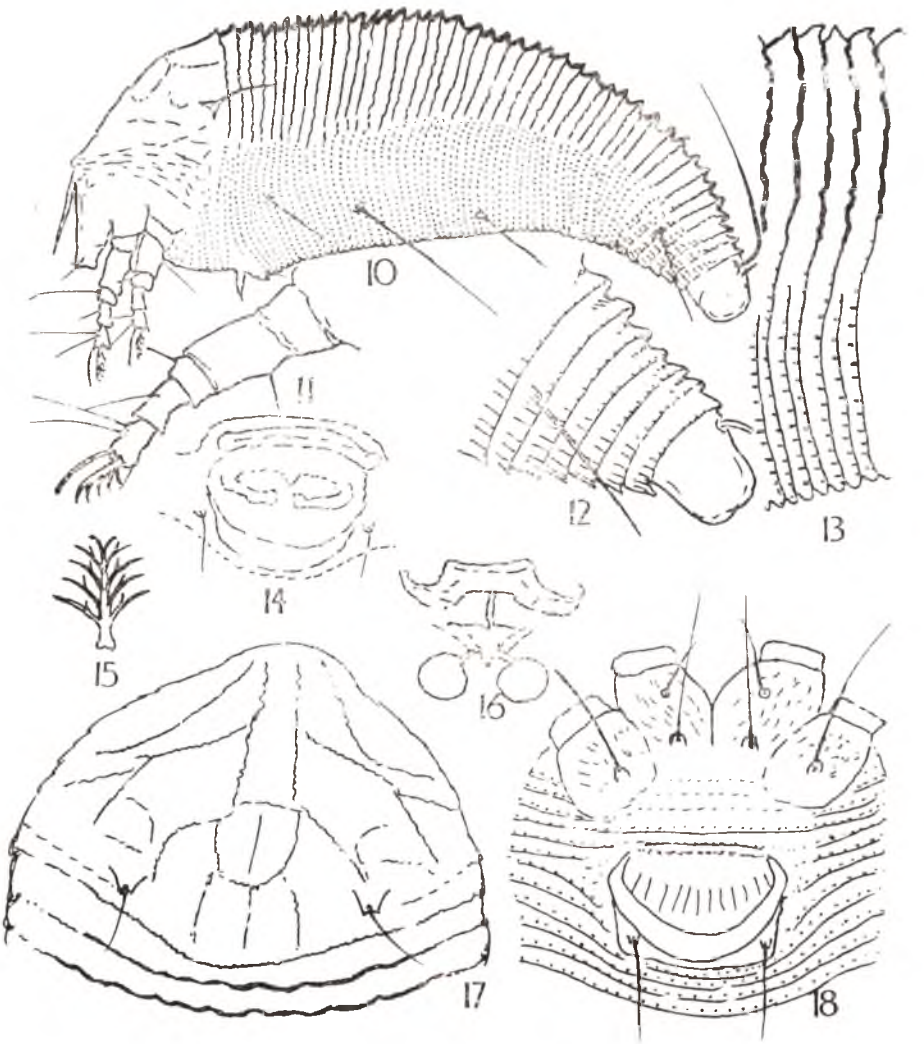


Phyllocoptes aliyamagarensis sp. nov. (Figs. 1—9). 1. Side view of mite; 2. Side view of cauda 3. Left fore leg; 4. Internal female apodeme; 5. Side skin structure; 6. Feather claw; 7. Male genitalia; 8. Dorsal view of shield; 9. Female genitalia and coxae from below.

NADU, Aliyamagar forest, Coll. Mohana Sundaram (No. 202). Host: Unidentified plant. Mites are under-surface leaf vagrants.

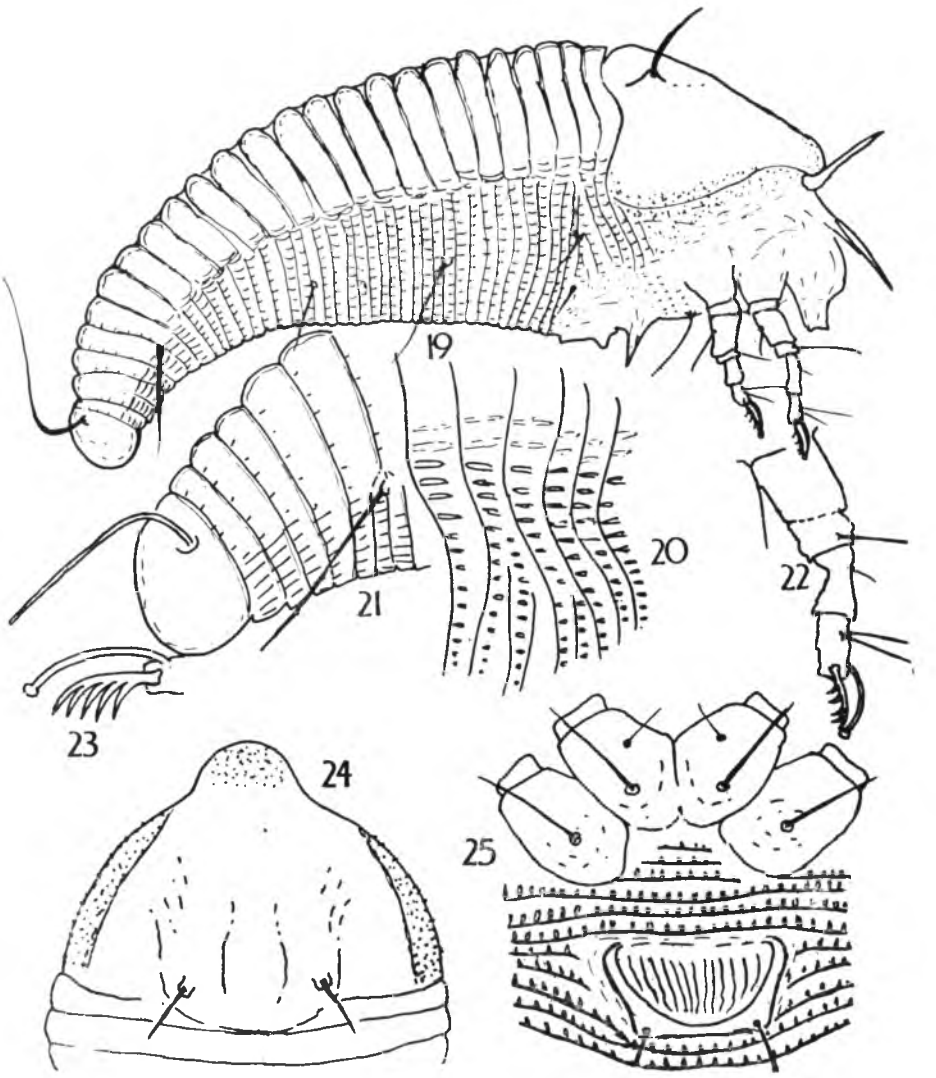
2. **Phyllocoptes indicae** sp. nov. (Figs. 10 to 18)

This mite resembles *Phyllocoptes fructiphilus* Keifer (1940 a) by its 5 rayed feather claw granular coxal area but differentiated from it by the shield pattern with wavy lines, finer microtuberculation, smoother tergites and the number of scorings on the female genital cover flap apart from the measurements. It is also near *Phyllocoptes abaenus* Keifer (1940a) by its shield pattern, but differentiated from it by the 5 rayed feather claw, smoother tergites, granular coxal area and the scorings on the female genital cover flap.



Phyllocoptes indicae sp. nov. (Figs. 10—18). 10. Side view of mite; 11. Left foreleg; 12. Side view of cauda; 13. Side skin structure; 14. Male genitalia; 15. Feather claw; 16. internal female apodeme; 17. Dorsal view of shield; 18. Female genitalia and coxae from below.

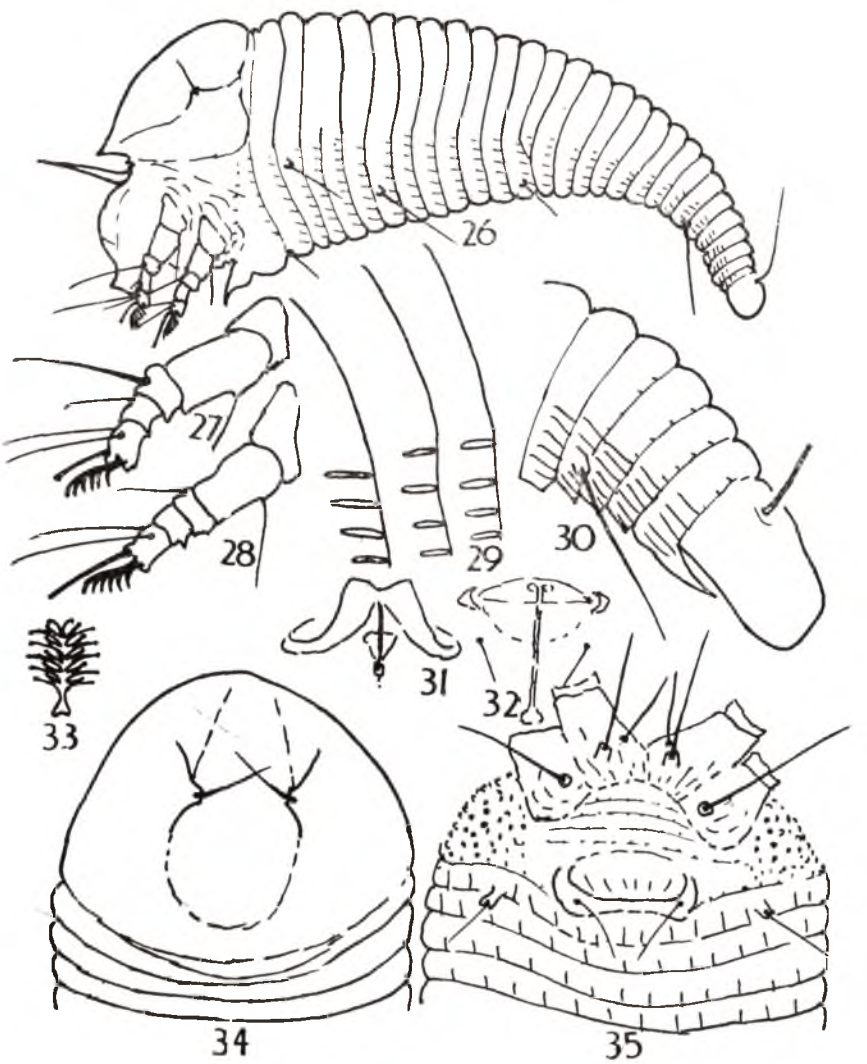
Female: 170—180 long: 50 thick: rostrum 15 long, pointing downwards; antapical seta 4 long; shield 45 wide, 35 long with a clear pattern of wavy lines; median represented in the rear half, admedians complete; four submedians running diagonally and joining with the admedians. Dorsal tubercles a little ahead from rear shield margin, 30 apart; dorsal setae 10 long, pointing backward and outward. Fore leg 25 long; tibia 6 long; tibial seta 5 long, at mid point; tarsus 5 long; claw 8 long: feather claw 5 rayed. Hind leg 23 long; tibia 5 long; tarsus 5 long; claw 8 long. Fore leg with the femoral patellar, tibial and tarsal setae while



Phyllocoptes asperaevagrans sp. nov. (Figs. 19—25). 19. Side view of mite; 20. Side skin structure; 21. Side view of cauda; 22. Left foreleg; 23. Feather claw; 24. Dorsal view of shield; 25. Female genitalia and coxae from below.

the hind leg with femoral, patellar and tarsal setae. Coxae with all three setiferous tubercles; coxal area with short scorings; seta I, 8 long; seta II, 20 long; seta III, 25 long. Abdomen with about 42 smooth wavy tergites, 65 microtuberculate sternites; lateral seta 25 long on ring 10; first ventral seta 35 long on ring 25; second ventral seta 16 long on ring 40; third ventral seta 25 long on ring 6 from behind; Caudal seta 68 long; accessory seta 3 long. Female genitalia 15 wide; 13 long; cover flap with 10—12 lines; genital seta 15 long.

Male: 170 long; 50 thick; genitalia 15 wide; genital seta 15 long.



Phyllocoptes simplicifoliae sp. nov. (Figs. 26—35). 26. Side view of mite; 27. Left foreleg; 28. Left hind leg; 29. Side skin structure; 30. Side view of cauda; 31. Internal female apodeme; 32. Male genitalia; 33. feather claw; 34. Dorsal view of shield; 35. Female genitalia and coxae from below.

Types: A **holotype** slide with 3 ♀♀ and 8 **paratype** slides with 3 ♂♂ and 3 ♀♀, INDIA, TAMIL NADU, near Kallar, 16. vi. 1975, Coll. Mohanasundaram (No. 165).

Host: *Anisomeles Indica* O. Kza (Labiatae) Mites found as under surface-leaf vagrants.

3. **Phyllocoptes asperaevagrans**, sp. nov. (Figs. 19-25).

This mite is near *Phyllocoptes aphrastus* Keifer (1940a) by its clear coxal area, scorings on the female genital cover flap and the shield pattern, but differentiated from it by the 5 rayed feather claw, granular anterior

tip and sides of the shield; microtuberculate sternites and the measurements. It differs from *Phyllocoptes aliyamagarensis* sp. nov, deseribed herein, by the position of the dorsal setae: granulations on the shield and the microtuberculation of the sternites.

Female: 150—160 long; 50 thick; rostrum 15 long; antapical seta 3 long. Shield 45 wide; 43 long; shield Projecting over rostrum base; anterior portion of shield faintly granulate, rest of the area showing faint mosaic pattern; sides of shield heavily granular; median absent; admedians broken, represented in the posterior half; three submedians represented by broken lines. Dorsal tubercles just ahead of rear shield margin; 20 apart, dorsal setae 9 long, pointing upward and outward. Foreleg 24 long; tibia 5 long, tibial seta 3 long at basal 1/3; tarsus 5 long, claw 5 long, curved and knobbed at tip; feather claw 5 rayed Hindleg 22 long, tibia 5 long: tarsus 5 long, claw 5 long, similar to fore claw. Fore leg with the usual femoral, petellar, tibial and tarsal setae, while the hind leg with the femoral, petellar and tarsal setae. Coxae with all three setiferous tubercles. Coxal area with a few scorings around 2nd and 3rd tubercles otherwise smooth; seta I, 8 long, seta II, 22 long, seta III, 25 long. Abdomen with about 25 broad, smooth tergites, 45 microtuberculate sternites: lateral seta 12 long on ring 7; first ventral seta 35 long on ring 16; second ventral seta 7 long on ring 27; third ventral seta 15 long on ring 6 from behind; caudal seta 35 long; accessory seta inconspicuous. Female genitalia away from coxal base 18 wide, 12 long; coverflap with 12-14 lines; genital seta 10 long.

Male: 110 long, 40 thick, genitalia 12 wide, genital seta 6 long.

Types: A **holotype** slide with 3 ♀♀ and 4 **paratype** slides with 3 ♂♂ and 3 ♀♀, INDIA, TAMIL NADU, Coimbatore, Kinathukada 24. vii. 1974, Coll. Mohanasundaram (No. 95).

4. Phyllocoptes simplicifoliae, sp.nov. (Figs.26—35)

This mite resembles *Phyllocoptes vandinei* Keifer (1940b) by the position of the shield setae, clear coxal area and the scorings on the female genital coverflap; but differentiated from it by the shield pattern, 6 rayed feather claw and the shape of the claw.

Female: 160—170 long; 50 thick; rostrum 29 long, down curved; antapical seta 3 long; shield 45 wide; 40 long, shield lobe projecting over rostrum base; admedians alone represented; dorsal tubercles away from shield margin at about the mid part of the shield; 12 apart, dorsal seta 10 long pointing upwards. Foreleg 22 long; tibia 3 long; tibial seta 7 long; tarsus 4 long; claw 5 long; knobbed at tip feather claw 6 rayed. Hindleg 18 long; tibia 2.5 long, tarsus 4 long, claw 7 long, slightly curved. Foreleg with the usual femoral, patellar, and tarsal setae, while the hindleg with the femoral, patellar, and tarsal setae. Coxae with all three setiferous tubercles, coxal area with few scorings; seta I, 12 long; seta II, 20 long; seta III 28 long. Abdomen with about 28 broad, smooth tergites; 45 microtuberculate stermites; microtubercules elongate; lateral seta 6 long on ring 3, first ventral seta 15 long on ring 14; third ventral seta 15 long on ring 4 from behind; caudal seta 15 long; accessory seta absent. Female genitalia a little away from coaxal base; 20 wide, 8 long, coverflap with six short lines; genital seta 5 long.

Male: 140 long; 50 thick; genitalia 17 wide; genital seta 5 long.

Types: A **holotype** slide with 3 ♀♀ and 6 **paratype** slides with 3 ♂♂ and 3 ♀♀, INDIA

TAMIL NADU, Nilgiris, Dhodebetta, Coll. Mohanasundaram (No. 231).

Host: *Miliosma simplicifolia* (Roxb) Walp. (Sabiaceae). Mites are under surface leaf vagrants.

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Entomon, 1981, *Vol.* **6**, *No.* 3, *pp.* 261 *to* 264

SPATIAL DISTRIBUTION PATTERN OF LEAFHOPPER (*AMRASCA BIGUTTULA BIGUTTULA* ISHIDA) ON OKRA *ABELMOSCHUS ESCULENTUS* MOENCH)

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(Received 16 August 1980)

Leafhoppers in okra have been found to follow aggregative distribution. This aggregation has been found to be that of colonies of fixed size. Rainfall has been found to reduce the mean density and increase aggregation among the insects.

(Key words:—aggregation, mean intensity, K-value, λ-value, Morisita's index of dispersion, Lloyd's index of patchiness)

INTRODUCTION

The individuals of a species of insects distribute themselves in their habitat with a characteristic pattern, depending both on the inherent properties of the species and conditions of the habitat. The analysis of spatial distribution is very important in insect population ecology for the following reasons.

i) The pattern of spatial distribution affects not only the precision of the estimation of population parameters in sampling, but also the method of analysis of the data, and ii) the spatial distribution itself is an important structure of the population. The distribution at a given time is determined by complex biological processes that were going on in the population by that time, and it may define or affect the subsequent change of the population. Therefore, information on the spatial distribution and changes in relation to population density and various environmental variables are fundamental to a full understanding of insect population dynamics which forms an integral part of pest management.

The aggregation pattern of various insects/animals have been studied earlier and excellent reviews have been made by IWAO, (1970 a, b) and SOUTHWOOD (1966). Earlier studies on leafhopper, distribution have been made by BOWEN (1974) and KUNO (1963, 1968) for the beet leafhopper, *Eutettix tenellus* and rice leafhopper, *Nephotettix cincticeps* and *Laodelphax striatellus* respectively. They reported that their distributions fitted the negative binomial series.

MATERIALS AND METHODS

An unprotected field of okra cv *Pusa Sawani* grown in 200 sq. metres was divided into 20 uniform stratas as suggested by HARCOURT (1961) and observations on leafhopper (*Amrasca biguttula biguttula* (ISHIDA) on ten plants in each strata were recorded. Six observations were recorded during

Contribution No. 1033 of Indian Institute of Horticultural Research, Bangalore-560 080.

the crop season commencing from 15 days after germination. The leafhopper population was estimated using the sampling technique suggested by KRISHNAIAH *et al.*, (1979). The spatial distribution patterns were studied using the methods described by SOUTHWOOD (1966) and IWAO and KUNO (1971).

RESULTS AND DISCUSSION

The mean intensity, variance, K-value, ARBOUS & KERRICH's (1951) λ-value, Morisita's first index of dispersion and its F-test value and Lloy'ds index of patchines are given in Table 1.

Since on all dates of observation, variance is more than the mean, an aggregation of jassids could be suspected and as K-values are less than 1, a logarithmic distribution is likely to fit the data (SOUTHWOOD, 1966). Similar results were observed in the experiment (Table 1). While the K-value was slightly higher, viz , 0.60 and 0.77 during the initial observations, there was drastic reduction in the subsequent observations suggesting an intense aggregation in the subsequent observations. The values also revealed that aggregation is mainly due to genetic and environmental causes (BLACKITH, 1958). The Morisita's index of dispersion and its F-test as well as the Lloyd's index of patchiness which in all the cases is more than 1, supports the conclusion about the aggregation of insects.

TABLE 1. Mean intensity and some measures of agregation of jassids on okra

Date of observations	Mean intensity	Variance	K	λ Value	Morisita's $I\delta$	F	Lloyds index of patchiness
6-10-79	4.54	12.12	0.60	1.72	2.08	6.28**	1.37
12-10-79	3.15	7.24	0.77	2.83	1.42	4.53**	1.41
27-10-79	11.33	72.28	0.19	13.57	1.46	6.37**	1.47
5-11-79	14.20	95.53	0.17	18.52	1.55	8.59**	1.40
12-11-79	11.77	78.47	0.18	15.18	1.51	6.94**	1.48
19-11-79	9.91	96.74	0.11	19.76	1.97	10.96**	1.87

** Significant at P (0.01) level of significance

TABLE 2. Correlation of meteorological parameters with mean intensity and aggregatian of insects.

	with Mean intensity	K
Rainfall (mm)	—.9414**	.9757**
Maximum temperature (°C)	—.5991	.7976*
Minimum temperature (°C)	—.8486	.7096
Relative humidity (%)	—0.0617	—0.2704

* Significant at 5% level ** Significant at 1% level.

To find out the environmental factors responsible for aggregation, the total rainfall (mm), absolute maximum and minimum temperature (°C) and mean relative humidity were correlated with the coefficient of aggregation (Table 2). From the table it was inferred that rainfall causes a decrease in the mean intensity but increases the aggregation and the maximum temperature also causes increase in the aggregation.

To get an insight into the type of aggregation involved, that is, whether it is an aggregation of insects in colonies or whether it is an aggregation of colonies the α and β of IWAO & KUNO (1971) were worked out. The values were 0.2065 and 1.4939 respectively. According to IWAO & KUNO (1971) this indicated that aggregation of insects under study are between colonies of almost equal size. Similar conclusions were arrived at by SYLVESTER & COX (1961) for green peach aphid in beet and pea aphid *(Macrosiphum pisi)* affecting alfalfa (FORSYTHE & GYRISCO, 1963). BERTHET & GERARD (1965) reported a similar phenomenon for the oribatid mites (*Oppia ornata)*. Wireworm larvae *(Limonius* spp.) occurring in soil was also found to follow a similar pattern (BLISS & OWEN, 1958).

Since the aggregation is between colonies rather than individuals, the results show that while rainfall promotes closer aggregation between colonies, it reduces the number of leafhoppers per colony thus reducing the mean density. Similarly, higher temperature causes the colonies to come closer together.

Acknowledgements:—The authors wish to express their sincere thanks and gratitude to Dr. G. S. RANDHAWA, Director, Indian Institute of Horticultural Research, Bangalore - 560 080 for providing necessary facilities for conducting the experiment. Thanks are also due to Dr. SUDHA NAGARKATTI, Head, Division of Entomology and Dr. V. G. PRASAD, Senior Entomologist for their keen interest and useful suggestions during the period of study. The technical assistance rendered by Mr. K. V. PRAKASH is appreciated.

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Entomon, 1981 *Vol.* 6, *No.* 3, *pp.* 265 *to* 269

SEQUENTIAL SAMPLING PLAN FOR THE ONION THRIPS, *THRIPS TABACI* (LIND.)

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(*Received 25 August 1980*)

Sequential sampling plan based on negative binomial distribution and providing for population estimates in three infestation classes, was developed for using in control of onion thrips, *Thrips tabaci* (Lind.). In addition OC-Curve and ASN were studied for predicting the probable number of plants required for different population densities.

(*Key words*:—sequential sampling, onion thrips, operating characteristic curve, average sample number).

INTRODUCTION

A sequential sampling plan which is characterized by its flexible sample size was originally developed for quality approval of manufactured goods. It is a sampling procedure where the samples are taken in sequence and decision depends on every unit included in the sample. It is advantageous because it allows rapid classification of population levels with minimum number of samples chosen following an appropriate procedure. In case of insect sampling, the population density fluctuates with time and a fixed sampling procedure cannot provide an accurate estimate of the population. Sequential sampling techniques have been developed for several economically important insect species including spruce budworms, *Choristoneura fumiferana* (CLEMENS) (MORRIS, 1954; WATERS, 1955), imported cabbageworm *Pieris rapae* (L.) (HARCOURT, 1966 a), white grubs (IVES & WARREN, 1965), cabbage looper, *Trichoplusia ni* (HUBNER) on cauliflower (HARCOURT, 1966 b) and corn earworm, *Heliothis zea* (BODDIE) (WOLFENBARGER & DARROCH, 1965). A sequential sampling procedure needs a very small number of samples when the population is low or high. With population density close to threshold value more samples are required for classification of the population. Thus sequential sampling techniques allow rapid yet accurate decisions to be made pertaining to treatment and also allow determination of the degree of control against a pest by a specific treatment. For the present study, a sequential sampling plan has been developed to evaluate the need for chemical control of onion thrips, *Thrips tabaci* (LIND.).

MATERIALS AND METHODS

Before a sequential sampling model can be developed mathematical distribution of the pest in the field must be known. SUMAN *et al.* (1980) determined the spatial pattern of onion thrips on onion as being of aggregative nature and was adequately fitted to negative binomial series, $(q-p)^{-k}$ where $p = \frac{m}{-k}$ and $q = 1+p$. The clumping parameter k used in the present calculations, 1.0243 is based on sampling data.

Two statistical hypotheses Ho and H1 were used to differentiate between levels that do and do not require treatment respectively. The two types of error used are

α = the probability of recommending an unnecessary treatment (i. e., accepting HI when Ho is the true condition): β = the probability of failing to recommend a needed treatment (i. e., accepting Ho when HI is the true condition). For sampling of onion thrips and were set at 0.15. This means that the risk of committing either type of error is 1 in 7. These errors were also set at .10 and .20 to work out average sample number.

The equations for decision lines are taken from OAKLAND (1950) and MORRIS (1954) and pertain to the negative binomial distribution. The lines for light versus moderate infestation classes are:

$d = bn + ho$ (lower line) and

$d = bn + hl$ (upper line)

where d is the cumulative number of thrips, n is number of plants sampled and b is the slope of the line. The slopes and intercepts are calculated as follows:

$$b = k \frac{\text{Log } \frac{q_1}{q_o}}{\text{Log } \frac{p_1 q_o}{q_1 p_o}}$$

$$h_o = \frac{\text{Log B}}{\text{Log } \frac{p_1 q_o}{p_o q_1}} \quad \text{where B} = \frac{\beta}{1-\alpha}$$

$$h_1 = \frac{\text{Log A}}{\text{Log } \frac{p_1 q_o}{p_o q_1}} \quad \text{where A} = \frac{1-\beta}{\alpha}$$

The following three infestation classes were used for the present study; (i) Light infestation = 5 or less thrips per plant; (ii) Moderate infestation = between 10 and 15 thrips per plant; (iii) Severe infestation = more than 20 thrips per plant.

The population between 5—10 and 15—20 thrips corresponds to indecisive zone for comparing light *vs* moderate and moderate *vs* high infestations respectively.

The operating characteristic curve (OC) which is a function of Ho was calculated as explained by OAKLAND (1950), using two equations related by dummy variable h.

Let L (p) be the probability of accepting Ho and m the population mean per sample. Then

$$L(p) = \frac{A^h - 1}{A^h - B^h} \; ; \; h \neq o$$

where A and B are defined earlier.

$$m = Kp = K \frac{1 - \left(\frac{q_1}{q_o}\right)^h}{\left(\frac{p_1 q_o}{p_o q_1}\right)^h - 1} \; ; \; h \neq o$$

and average sample number was worked from the formula

$$E(n) = \frac{h_1 + (h_o - h_1)\, L(p)}{K_p - b}$$

Although these curves are not essential in the application of sequential sampling plan, they are helpful in visualizing its performance.

RESULTS AND DISCUSSION

The decision lines for light versus moderate (5 vr 10)

$d = 6.9669\, n - 19.5236$

$d = 6.9669\, n + 19.5236$

and moderate versus severe

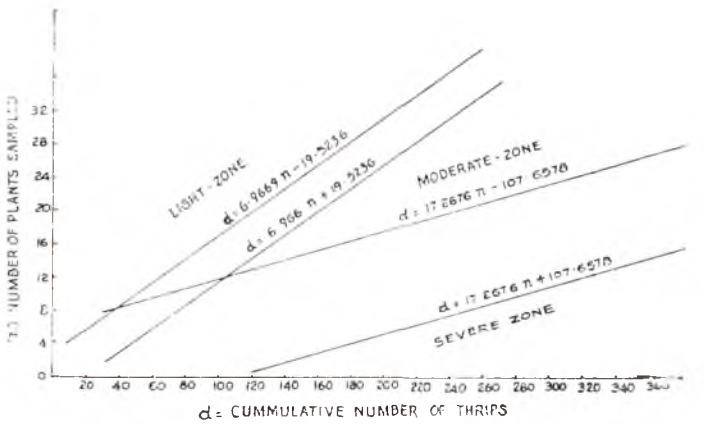

Fig. 1. Sequential Sampling Graph for $\alpha = \beta = 0.15$.

TAALE 1. Sequential sampling table for treatment decision on the onion thrips, *Thrips tabaci*.

No. of plants	Light vs. Moderate Infestation $\alpha = \beta = 0.15$		Moderate vs. Severe Infestation $\alpha = \beta = 0.15$	
1	0	26	0	125
2	0	33	0	142
3	1	40	0	159
4	8	47	0	176
5	15	54	0	194
6	22	61	0	211
7	29	68	13	229
8	36	75	30	246
9	43	82	48	263
10	50	89	65	280
11	57	96	82	298
12	64	103	100	315
13	71	110	117	332
14	78	117	134	349
15	85	124	151	367

$$d = 17.2676\ n - 107.6758$$
$$d = 17.2676\ n + 107.6758$$

are plotted in Fig. 1 for rating infestation classes for making treatment decision. The numerical values of variable d for various values of n, called sequential sampling table, are given in Table 1. In the field it is easier to use a sequential sampling table based on sequential graph than to use the graph itself. For using this table, plants should be selected at random for counts of thrips popula ions per plant. The running totals of thrips populations are to be checked against the table after every unit has been selected. Sampling is to be continued so long as the total remains within the light versus moderate or moderate versus severe bands till a decision is achieved.

The operating characteristic curve (Fig. 2) gives the probability L (p) of reaching a correct decision for a range of population means. When the mean (kp) is 4.8 the probability of labeling infestation light is 0.9 Hence the probability of labeling it moderate is 0.1. When the mean is 11.2, the probability of labeling infestation light is 0.1 and as moderate is 0.9. As the mean decreases below 11.2 or increases above 4.8, the probability of reaching the correct decision is less. Finally the density level reached 6.9, where the chances of labeling the infestation, light or moderate are equal. The curve for moderate versus severe can be used similarly.

The ASN curve for different levels of α and β for light versus moderate and moderate versus severe are presented in Figs. 3 and 4 respectively. tThe average sample number function can be used to predict the average number of plants which must be sampled under different sequential plans and it is useful in comparing the efficiency

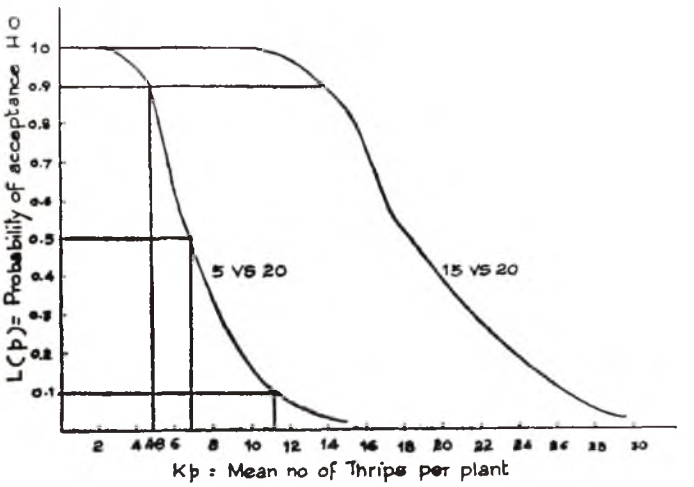

Fig. 2. Operating characteristic curve of sequential sampling plan.

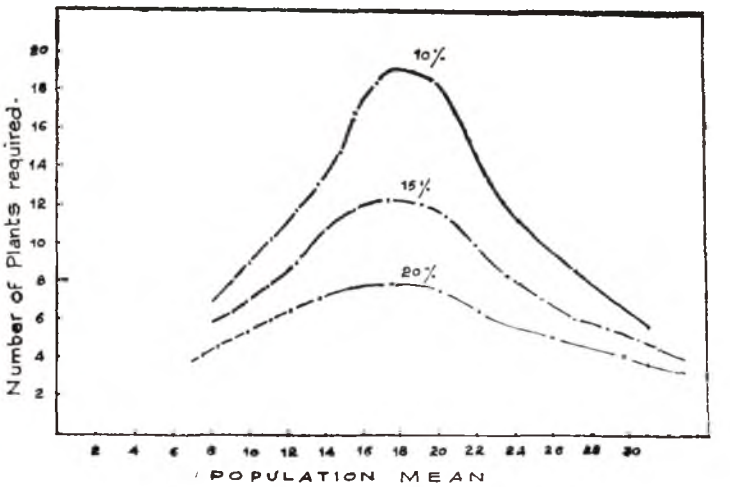

Fig. 3. Average sample number curves for different levels of α and β (15 vs 20).

of different plans. As the mean density of population is 2 thrips per plant the average sample numbers are 3,4 and 5 plants for α and β set at .20, .15 and .1 respectively for 5 *vs* 10. The curves reached maximum near kp=6.0 corresponding to 5,7 and 11 plants and fell rapidly for further increase of mean. Similarly the curve of moderate *vs* severe (15 *vs*. 20) reached maximum for kp=18 corresponding to 8,12 and 19 ASN but declined rapidly when populations were of greater or lesser density.

Acknowledgements:—We are thankful to Dr. G. S. RANDHAWA, Ex-director and Dr. (Mrs.) SUDHA NAGARKATTI, Sr. Scientist for encouragement and facilities through out the study.

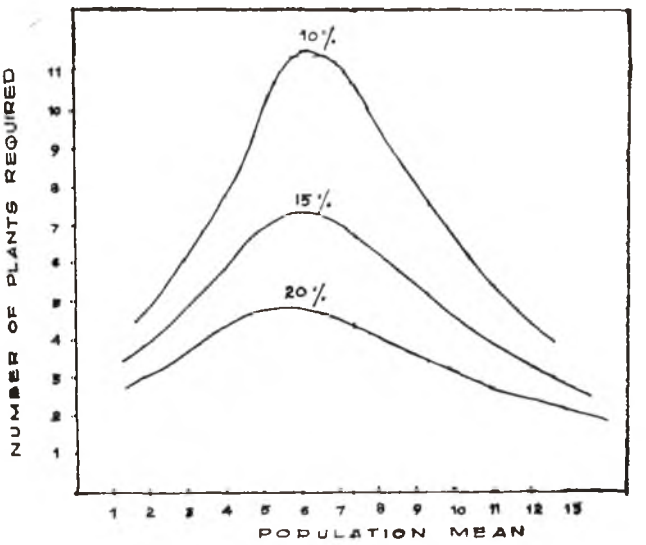

Fig. 4. Average sample number curves for different levels of α and β (5 vs 10).

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DISTRIBUTION PATTERN OF BLISTER BEETLE, (*MYLABRIS PUSTULATA* THUNB.) UNDER NATURAL CONDITIONS

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(Received 16 September 1980)

Distribution pattern of blister beetle *Mylabris pustulata* (Thunb.) was studied under natural conditions. Morisita's index and Iwao's regression method indicatad aggregative nature of dispersion of the population. Arbous and Kerrich criterion revealed that aggregation could be attributed to environmental effects. All the nine sets of data were adequately fitted to the negative binomial distribution and common k was found to be 0.8609. The sample size with 10 and 20 percent of standard error was also worked out.

INTRODUCTION

Adults of the blister beetle, *Mylabris pustulata* (THUNB.) are polyphagous and cause severe damage to several crops in the flowering stage. They feed upon the flowers of cucurbitaceous plants such as melon, pumpkin, cucumber, gourd, pulse crops like red gram, cowpea, soybean and malvaceous crops like okra and cotton (SINGH, 1970). Damage to anthers and petals of flowers causes drastic reduction in fruit setting and subsequently, yield.

The distribution patterns of insect populations under natural conditions give information needed for formulating management strategies for their control. The distribution behaviour of pests also affects the sampling programme, method of analysis of data and investigations on dynamics of pest populations when changes in size are considered. It also serves to justify further statistical analysis for suitable transformation to stabilize variance and satisfy basic assumptions for analysis of variance.

Contribution No. 1027 of the Indian Institute of Horticultural Research.

The distribution behaviour of a pest population approximates to random distribution (Poisson) when each individual has low but equal and independent chance of occurring on each of the sampling units. Such type of dispersion patterns of pest populations are rare in nature because most populations rarely disperse randomly when affected by physical and ecological factors as explained by TAYLOR (1961). In most cases populations follow (clumped) distribution in which the presence of one or more individuals at a unit will increase the chance of finding more individuals in the same unit. In view of these requirements, the present investigation was conducted to study the distribution pattern of the blister beetle, *Mylabris pustulata* on red gram *(Cajanus cajan)*.

MATERIAL AND METHODS

The experiment was conducted at the Experimental Research Station of the Indian Institute of Horticultural Research, Bangalore. Redgram variety *Extra Early Plant*—A_2 was sown on February 5, 1980 and was spaced at a distance of 50 cm between rows and 30 cm within the row. The crop was raised without resorting to any plant protection measures to allow the

pest population to build up under natural conditions. The plant was taken as the basic unit of sampling for observations. Nine sets of observations on number of beetles per plant were made from April 7, 1980 to June 2, 1980. Further, these sets of observations were summarised in the form of Frequency Tables for statistical analysis and fitting of distribution.

MORISITA's (1962, 1964) index of dispersion was used to determine the nature as:

$$I = N \frac{\Sigma xi\ (xi - 1)}{T\ (T - 1)}$$

where T is total number of individuals observed, xi is number of individuals at i-th unit and N is the total number of sampling units. This index gives a value of unity, less than unity or greater than unity for random, regular or contagious distribution, respectively. The departure from randomness shown by the index can be tested by comparing Fo as

$$Fo = \frac{I\ (\Sigma xi - 1) + N - \Sigma x}{N - 1}$$

with Table value of F where $N_1 = N - 1$ and $N_2 = \infty$

IWAO's (1968) repression method was used to determine the degree of aggregation. It provides a relationship between LLOYD's (1967) mean crowding m* and mean density m. These parameters were replaced by sampling estimates x*and $\bar{x}$ for the purpose of calculations,

ARBOUS and KERRICH's (1951) criterion was used to determine the cause of aggregation. Many workers (e. g., ANSCOMBE, 1949; WADLEY, 1950; EVANS, 1953; BLISS & OWEN, 1958 and SUMAN *et al.*, 1980 a, b) have shown that contagious populations can be adequately expressed by negative binomial distribution which is expressed by two parameters, mean m and exponent k. An important characteristic of this distribution is that variance is greater than the mean. The first approximation to 'k' was computed from the formula.

$$k = \frac{\bar{X}^2}{\delta^2 - \bar{X}}$$

where $\bar{X}$ and δ^2 are sample estimates of population mean and variance. This value of k was used to compute the maximum likelihood estimate of k as described by FISHER (1953) and was used to fit the negative binomial distribution to the counts of blister beetle for all the sets separately.

The regression method given by BLISS & OWEN (1958) was used to calculate common value of k. The appropriate sample size with desired degree of precision for the population following negative binomial distribution was worked out following the method given by RAJOS (1964).

RESULTS AND DISCUSSION

The statistical parameters for dispersion behaviour of blister beetle are shown in Table 1. For all the sets of observations, the variance was found greater than mean indicating the aggregative tendency of the population. As the population density increases the variance also increases and clustering of the population was not distinguishable at higher levels of population density. The value of dispersion parameter K (WATERS, 1959) was found to be less than one except on May 26. Ecologically, these values suggest that the population of blister beetle has a relatively stable and high degree of aggregation despite differences in mean levels of density. From a practical point of view, stability of relative dispersion in terms of K is of great importance to establish sequential sampling plans with desired degree of precision.

The ratio of mean crowding (LLOYD, 1967) to mean density $x^*/\bar{x}$ is an appropriate index of aggregation relative to mean. This index which showed a value greater than unity for all the sets further revealed that population follows contagious distribution. The stability of $x^*/\bar{x}$ ratio suggests that the clustering of populations among units tends to attain uniformity and the number of clusters increases with increase in population density. The relationship between mean crowding and mean density was adequately fitted by linear mode $x^* = 0.7175 + 1.6563\ \bar{x}$, which explained 90.16 percent of the distribution behaviour of the pest population. The value of

TABLE 1. Statistical parameters for dispersion behaviour of blister beetle *Mylabris pustulala* THUNB.

Date of observation	No. of units observed	Mean $\bar{x}$	Variance	K	X*	X*/$\bar{x}$	I	Fo	h	D. F.	Probability of Fit	Sample size 10%	Sample size 20%
April 7	623	0.7063	1.4554	0.7127	1.7669	2.5016	2.5026	2.0606	0.4099	4 2.2450	0.5–0.7	258	64
April 14	697	0.7604	1.7572	0.5805	2.0713	2.7239	2.7247	2.3109	4.4199	4 3.4432	0.3–0.7	248	62
April 21	643	0.7309	1.2780	0.9011	1.4794	2.0241	2.0247	1.7485	0.4866	4 2.1019	0.7–0.8	253	63
April 28	655	0.7557	1.8913	0.5357	2.2584	2.9885	2.9895	2.5027	0.3566	4 3.6095	0.3–0.5	249	62
May 5	652	1.4401	4.0471	0.7418	3.2504	2.2571	2.2565	2.8103	0.8935	6 5.4407	0.3–0.5	186	46
May 12	664	1.5813	4.9014	0.6864	3.6809	2.3278	2.3105	3.0840	0.9531	7 3.8907	0.5–0.7	179	45
May 19	650	1.7477	4.7560	0.8235	3.4689	1.9848	1.9842	2.7213	1.1923	713.9905	0.02–0.05	173	43
May 26	661	1.9516	5.2037	1.1325	3.6180	1.8532	1.8532	2.6664	1.1447	7 3.8287	0.70	167	42
June 2	602	1.5631	4.5526	0.7484	3.4756	2.2236	2.2228	2.9125	0.9128	7 9.7296	0.10–0.2	180	45

regression co-efficient which was significantly greater than unity, confirmed the aggregative nature of dispersion. Further, this model also suggests that the rate of increase of co-efficient of dispersion is greater than unity with different levels of population. MORISITA'S (1964) index of dispersion which is independent of parental distribution, has also shown values greater than unity for all the sets. Ecologically, this index indicated that clumping was an important characteristic associated with fluctuation of the population density. Also the highly significant value of Fo shown by the index for all the sets highlights the departure from randomness and a tendency for aggregation of the population.

ARBOUS & KERRICH'S (1951) formula has shown the value of h to be less than two for all the sets. Therefore, the cause of aggregation may be attributed to enviornmental effects and not due to the active processes of the insect.

The negative binomial distribution was fitted with maximum likelihood estimate of 'k' dispersion parameter. The value of chi-square and probability of fit shown in Table 1 indicated good agreement between observed and expected frequencies except on May 19. The possible reason for this departure may be because of heavy rain on the previous night. The value of common k was worked out to be 0.8609 which can be appropriately utilised for sequential sampling plan.

Number of units required for estimation of population with 10 and 20 percent of standard error of mean are shown in the last columns of Table 1. These estimates showed that the number of units required decreased with the increase of population density.

Acknowledgements:—We are thankful to Dr. (Mrs.) SUDHA NAGARKATTI, Senior Scientist of the Indian Institute of Horticultural Research for suggestions and improvement of the manuscript and to Mr. CLEMENT PETER for his valuable assistance throughout the study.

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Entomon, 1981, *Vol.* 6, *No.* 3, *pp.* 275 *to* 277

BRIEF COMMUNICATION

DISPERSION OF ONION THRIPS *THRIPS TABACI* (LINDAMAN)

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(Received 28 June 1980)

Studies on dispersion of onion thrips indicated that the thrips followed the contagious pattern. Negative binomial distribution did not fit at high densities of onion thrips and the reasons for aggregations could be either environmental and or behavioural.

The dispersion, the description of the pattern of distribution of animals in space, is of considerable ecological significance. Notably does it affect, the sampling programme, and the method of analysis of data, but it may be used to give a measure of poplation size and description of the condition of population. The insect distribution can either be random or non-random. Most commonly in contagious insect population, the variance will be larger than the mean. As as a result many contagious insect populations that have been studied can adequately be expressed by negative binomial distribution (HARCOURT, 1965; SUMAN *et al.*, 1980). As no information is available on the distribution pattern of onion thrips except for a solitary report by SUMAN *et al.* (1980), an attempt was made to study the dispersion on onion thrips.

Onion crop was planted in first week of October, 1979 in 39 plots of 2 × 2 m at Agricultural Research Station, Hagari, Bellary district, Karnataka. On 50th day, five plants from each plot were cut to ground level at random and carefully enclosed in a polythene bag individually fastened by rubber band. The thrips were counted by unfolding the leaf blades one by one under a magnifying glass in the laboratory. The data so collected from 195 samples were analysed for MORISITA'S (1962) index of dispersion, and tested for the goodness of fit of negative binomial distribution, by adopting third moment test (EVANS, 1953).

a) MORISITA'S (1962) index of dispersion was utilized as a measure of dispersion pattern and calculated from equation I (Fig. I), Where N = total samples, x = the sum of members of idividuals found in all the samples.

The significance of the departure from random distribution as shown by the above index is tested by comparing the F_0 value which is calculated from equation II (Fig. I).

b) Testing for goodness of fit of negative binomial distribution by (Skewness) : The 'T' value is calculated from equation III (Fig. I) where $\overline{X}$ = mean and S^2 = variance.

The 'T' value is compared with its standard error which is calculated from equation IV (Fig. I).

Where symbols are as above and k = dispersion parameter, various values of k are substituted in the equation V, Fig. I where n_0 = number of samples containing

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$$k = N\frac{\Sigma X^2 - \Sigma X}{(\Sigma X)^2 - \Sigma X} \quad \text{---------- I}$$

$$F_o = \frac{k(\Sigma X - 1) + N - \Sigma X}{N-1} \quad \text{---------- II}$$

$$T = \left(\frac{\Sigma f x^3 - 3\bar{x}\Sigma f x^2 + 2\bar{x}^2 \Sigma f x}{N}\right) - s^2\left(\frac{2\bar{x}^2}{s^2} - 1\right) \text{--- III}$$

$$S.E.(T) = \sqrt{\frac{2s^2(k+1)\frac{\bar{x}^2}{k^2}\left(1+\frac{\bar{x}}{k}\right)^2\left[2\left(3+5\frac{\bar{x}}{k}\right)-3k\left(1-\frac{\bar{x}}{k}\right)\right]}{N}} \quad \text{IV}$$

$$\log\left(\frac{N}{n_0}\right) = k\log\left(1+\frac{\bar{x}}{k}\right) \quad \text{---------- V}$$

$$\lambda = \frac{\bar{x}}{2k}v \quad \text{---------- VI}$$

thrips, until the two sides are equal (ANSCOMBE, 1950).

This method is reasonably efficient for most populations where clumping or aggregation is noticed (Southwood, 1966).

c) The mean size of clump (λ) is calculated from equation VI (Fig. 1) where X = mean, v = function with x^2 distribution with 2k degrees of freedom, λ = number of individuals in the aggregate for the probability allocated to v. To find out the mean size of 'aggregate' the value at the 0.5 probability level is used (ARBOUS & KERRICH, 1951).

The data of the counted thrips are given in the Table 1.

The MORISITA'S index (1.9967) was found to be greater than one and the departure from random distribution (F_o) was found to be significant. The variance (128.65) was also found to be greater than mean (10.85). With these facts and also supported by the findings of SUMAN *et al.* (1980) it is accepted that the thrips population in the present study followed a contagious pattern.

The third moment test was used to test the goodness of fit of negative binomial distribution, since the mean was large (EVANS, 1953). The 'T' value (—435.08), the difference between the skewness of data and its value predicted from the mean and variance, being numerically larger than critial difference (295.94) it may be said that the distribution of thrips does not fit into negative binomial pattern which

TABLE 1. The data on the count of thrips.

Number of thrips/plant (x)	No. of plants (f)	(x)	(f)	(x)	(f)	(x)	(f)
0	26	11	6	22	7	33—40	0
1	7	12	9	23	2	41	1
2	14	13	3	24	3	42	2
3	9	14	3	25	2	43—49	0
4	12	15	4	26	2	50	1
5	15	16	2	27	1	51—54	0
6	9	17	8	28	1	55	1
7	10	18	1	29	1	56	1
8	4	19	2	30		57—60	0
9	8	20	4	31	1	1	1
10	3	21	2	32	5		

is contrary to the findings of SUMAN *et al.* 1980). In the present study the mean density of thrips (10.85/plant) was far higher than that reported by SUMAN *et al.* (1980). Therefore it is possible that the non-fitting of the negative binomial distribution is due to the higher value of the density.

The mean size of clump (6.005), as calculated by ARBOUS & KERRICH (1951) formula being larger than two suggests that the aggregation of two or more insects could be due to environmental factors or active process. Similar reports in support of environmental or behavioural process accounting clumping for nature are provided by HARCOURT (1961) in *Pieris rapae* L. and JAYARATHNAM (1977) in *Plutella xylostella* L. However, SUMAN *et al.* (1980) from their studies on distribution of onion thrips, concluded that the aggregation nature is entirely due to environmental factors, since the mean size of the clump was smaller than two.

From the above evidences, it can be concluded that the negative binomial distribution did not fit at high densities of onion thrips and the reasons for aggregations could be either environmental and/or behavioural.

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REPORTS AND NEW RECORDS

AN IDEAL INSECT PRESERVATION TECHNIQUE

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(Received 11 April 1980)

Long term preservation of valuable insect specimens for reference and/or display is possible only by the adoption of an effective and relatively inexpensive storage echnique. Dry pinned insects are at present commonly stored in insect boxes of different sizes. Such boxes require periodical inspection and treatment with suitable preservative chemicals.

A simple, efficient technique for the long term storage of dry pinned insect specimens has been developed and this is described in this note.

Cylindrical museum jars, prefeferably 250 ml capacity, with screw-cap are used for insect preservation in the present method. Quality snow white cards of appropriate size are prepared for insertion into the bottle. Somewhat thicker snow white cards are preferable to ensure that there is no sagging. Cards of size 120×55 mm will be adequate for a bottle of 250ml capacity.

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High density thermocole of about 15—20 mm thickness and of suitable size are pasted to the card using Fevicol or some other synthetic adhesives. Dry specimens are pinned on to the pith and inserted into the bottle (Fig. 1). One naphthalene tablet is kept inside the bottle which is then closed air tight. The bottles containing insect specimens may be kept in display shelves or steel almirahs after catalogueing.

The present method facilitates close visual examination of the preserved specimens from outside, without opening the bottle and the fungus and insect infestations are negligible in the present method.

BOOK NOTICES

PROGRESS IN SOIL BIOLOGY & ECOLOGY IN INDIA

Edited by G. K. VEERESH, 1981, x + 351 pp. University of Agricultural Sciences, Bangalore 560 024. Technical Series No. 37. Price not indicated.

This volume contains the papers presented in the Second All India Symposium on Soil Biology and Ecology held at Bangalore in April, 1979. Systematics, Ecology, Biology and Control of different groups of soil organisms have been covered under 11 heads. Forty three full papers and 21 abstracts in this volume deal with insects and terrestrial arthropods like pseudoscorpions, mites spiders and millepedes. This compilation of research papers and reviews would be of considerable interest and utility to students of Soil Biology in India and the tropics. The coverage of subjects is rather wide and the printing and the general get up of the publication is satisfactory.

N. R. PRABHOO

RECENT ADVANCES IN ENTOMOLOGY IN INDIA

Edited by T. N. ANANTHAKRISHNAN, 1981, 162 pp. Published jointly by the Entomology Research Institute and M/S S. Viswanathan (Printers and Publishers) Madras, 600 031. Price : Individuals : Rs. 75/-; Institutions : Rs. 100/-; Foreign: US $ 20/-.

This publication incorporates the proceedings of a seminar held at Madras in February 1981 in connection with the birth centenary of T. V. RAMAKRISHNA AYYAR the reknowned Indian Entomologist. Fifteen reviews are included in it surveying the progress made in India in diverse fields of entomological research during the last three decades. The reviews are primarily intended to sustain and promote further interest in certain fields of entomological studies especially involving an interdisciplinary approach. The broad areas covered are forest entomology, sugarcane entomology, insect endocrinology, soil entomology, cecidology, insect pathology, hormonal control of insect pests, biological control of vectors, integrated control of agricultural pests, biochemistry of insect nervous system and bioenergetics, especially in relation to acridids. Most of the reviews have highlighted the more important Indian works providing a fairly extensive, if not exhaustive, bibliography. The printing is done on good quality paper and the general get up of the book is also good.

N. R. PRABHOO

BOOK REVIEWS

TEACHING OF INSECT PATHOLOGY IN RELATION TO BIOLOGICAL CONTROL OF PESTS & DISEASES

Edited by G. K. VEERESH, 1980, iv + 151 pp. University of Agricultural Sciences, Bangalore 560 024. Technical series No. 34, Price not indicated.

This is a manual incorporating 20 lectures delivered by respective authors to the participants of a Summer School held in June 1979 at the University of Agricultural Sciences, Bangalore. There are six lectures in this book which are of a general nature giving an idea as to how insect pathology could assist formulation of programmes for the Biological Control of insect pests. Seven lectures deal with diseases caused by fungi, bacteria, viruses, ricketsias, spiroplasms, protozoans and nematodes. Some of the lectures also give

techniques to be employed for the study. One lecture deals with mass culturing of certain pathogens, one with serological techniques and two with techniques employed in electron microscopy. One lecture considers in brief the defence strategies found in insects against pathogens and another gives an account of noninfectious diseases that can be caused to insects as for example by treating the insects with hormones bringing about metabolic derangements. Each of these lectures is designed to provide some background information to teachers and also research workers who are not familar with studies in insect pathology.

N. R. PRABHOO

COLEMANIA—an internationai journal of entomology

This is the third journal of entomology that is being published from India in the course of the last two decades. In recent times there has been a substantial increase in the number of persons who have become actively interested in the study of insects from different angles. Naturally the existing journals are finding it difficult to accommodate all the good research papers that are sent to them. Under these circumstances one may be required to wait for more than a year for getting a research paper published. The birth of this new journal perhaps would help mitigating the problems of entomologists and of entomological journals in this country. *Colemania* intends to cater to the needs of both basic and applied entomological research and wishes to be broad based in order to promote the interests in all branches of insect study, including groups like ticks and mites. There are nine papers and three research notes in the first issue of the journal having 70 pages. Two papers are in agricultural entomology, one each in biological control and in techniques while eight are on systematic entomology. The journal has an attractive format and the printing is done almost free of mistakes on good quality paper. The line drawings and photographs are well reproduced. The journal has an impressive editorial board on which many well known entomologists are included. It can expect good response from individuals and institutions alike. One might feel that the first issue of the journal weighs a little too heavily in favour of systematic entomology and one would expect the publisher to strike an even balance among the various lines of entomological study.

There are to be three issues of the journal a year (April, August, December) and the rates of subscriptions are—Individuals: Rs 60 (Indian); or US $ 20/- (foreign) or US $ 10/- (LDC's); Institutions: Rs. 150/- (Indian); or US $ 45/- (foreign) or US $ 25/- (LDC's).

N. R. PRABHOO

TERMITE CONTROL IN EUCALYPT PLANTATIONS

by K. S. S. Nair and R. V. Varma 1981, 48 pp. Research report—6. Kerala forest Research Institute, Peechi 680 653. Not priced.

This is a consolidated report of the field studies conducted in the experimental forest sites in Kerala for a period of four years from 1976—1980 in order to evolove a standardized procedure for control of termites in the eucalypt plantations in the state. Termite damage has been recognised as a major draw back for the successful establishment of eucalypt plantions in the state. The publication under review has brought to light several interesting points which would serve as guide lines to all those

interested in raising eucalypt plantations in he state. Termites have been found to cause 20—80% mortality in the field to transplanted seedlings of *Eucalyptus tereticornis* in the course of the first year, while mortality during the course of subsequent years has been found to be negligible. It was found in this study that remedial measures that could be taken in the plantations after the incidence of termite attack are cumbersome and not very effective. The authors therefore conclude that effective prophylactic measures of control have to be employed before the seedlings are planted out. Attempts have been made by the authors to evolve control measures which are "effective and at the same time simple, economic and reasonably free from pollution hazards". An interesting point that has been brought to light is that out of the seventeen species of termites that have been found to be associated with eucalypt plantations in the state only six were found to be injurious to plantations and out of these latter only four caused lethal damage to the plant. Further, as the above species do not build conspicuous mounds, absence of the latter in the field does not preclude the threat from termites, thus making the prophylactic treatment of the seedlings with insecticides an obligatory exercise. There is a short but precise account of the insecticidal trials in the field leading to specific recommendations which could be readily followed by laymen as is intended. There is also a short account dealing with the ecological aspects of the problem. This booklet will be of considerable use to foresters. One is likely to notice the lack of information on possibiliiies of employing biological control as an alternative to chemical control of termites especially when the authors maintain that "it must be recognised that termites are an important component of tropical ecosystems and that it is neither feasible nor desirable to exterminate them".

N. R. PRABHOO

ANNOUNCEMENT

An All India Symposium on Vectors and Vector-borne Diseases covering biology and control of vectors of public health, veterinary and agricultural importance will be held in Trivandrum under the joint auspices of the Department of Zoology, University of Kerala and the Association of Microbiologists of India, Trivandrum Unit. The Symposium is scheduled for February (26th—28th) 1982. Further details can be had from the Convener, Dr. R. Sripathy Prasad, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695 581.

OBITUARY

Dr. Govindbhai Motilal TALATI was born on 5th April 1929, at Umreth in Kaira district of Gujarat. He studied at College of Agriculture, Poona and Aanad and got B. Sc. (Agri.) (Honours) degree of University of Bombay in 1950. He worked as Statistical Assistant in the Department of Agriculture at Poona till 1953; Agricultural Extention Officer till 1958 and Block Development Officer, Balsar and Surat Districts till 1966. He was deputed by the Government of Gujarat for higher training abroad and joined Texas (Agricultural & Mechanical) University at College Station, Texas in July 1966. He studied there for four years and got M. Sc. and Ph. D. degrees. On his return to India he joined as Assistant Entomologist at Junagadh (Gujarat) in 1970, where he established the Pesticide Testing Laboratory. In 1971 he was promoted as Professor of Entomology (Post Graduate) at College of Agriculture, Junagadh and in 1971 he also assumed the charge of State Agricultural Entomologist. With the inception of Gujarat Agricultural University, he became Professor and Head of Department of Entomology. In addition he also worked as Principal Investigator for a PL-480 scheme entitled "Study of the factors contributing to winter survival of pink bollworm of cotton in Gujarat."

During his service of 11 years as Professor he guided 19 M. Sc. (Agri.) and 2 Ph. D. students and published 43 research papers and popular articles in various English and Gujarati journals and magazines in India and abroad. He also took active part in Lab to Land programme of ICAR and popularised the integrated pest control against sugarcane and coconut pests. His work on biological control of pink mealy bug of sugarcane and black headed caterpillar of coconut is praiseworthy.

On 9th May 1981, he met with an accident when he was returning to Junagad from Surat after attending the Plant Protection Sub-Committee meeting. He breathed his last on 11th May 1981. He is survived by his wife Shantaben, and son Jayantbhai. In his passing away India has lost one of the foremost Entomologists.

DHAMO K. BUTANI

COLEMANIA

(An International Journal of Entomology)

COLEMANIA, an international journal of basic and applied entomology, will publish original papers and notes of high standard dealing with results of research carried out in any part of the world, within one year of receipt of the manuscript, as far as possible. There will be three issues a year (April, August, December) of this "fully refereed journal" assisted by an Editorial Board of international specialists. Book Reviews and Notices, News & Notes, advertisements and other pertinent information will also be included.

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(INAUGURAL ISSUE PUBLISHED IN APRIL 1981)

Reg. No. R. N. 9386 / 76

ENTOMON is covered in the following abstracting / indexing journals: *Chemical Abstracts* (Chemical Abstracts Service, The Ohio State University, Columbus, Ohio 43210, U. S. A.), *Review of Applied Entomology* (Commonwealth Institute of Entomology, 56 Queen's Gate, London SW7 5JR, England), *Current Contents / Agriculture, Biology & Environmental Sciences* (Institute of Scientific Information, 3501 Market Street, Philadelphia, Pa. 19104, U. S. A.), *Biological Abstracts* (Biosciences Information Service, 2100 Arch Street, Philadelphia, Pa. 19103, U. S. A.), *Entomology Abstracts* and other relevant *Abstracts* (Information Retrieval Limited, 1 Falconberg Court, London WIV 5FG, England), *Referativnyi Zhurnal* (The Insitute of Scientific Information, Academy of Science of the U. S. S. R., Baltijskaya ul., 14, Moscow A—219, U. S. S. R.).

Printed by V. K. K. Prabhu at GEO Printers, Plamood, Trivandrum 695 004
for the Association for Advancement of Entomology.

ENTOMON

Entomon is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September, and December, devoted to publication of research work on various aspects of insects and other land arthropods excluding gross anatomy, histology and morphology.

Address MS and all editorial correspondence to the Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695 581.

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Annual subscription for institutions: Rs 80/- (in India); $ 30/- (abroad)
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